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LITIGATION TECHNICAL SUPPORT AND SERVICES

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ROCKY MOUNTAIN ARSENAL

# SECTIONS 26 AND 35 CONTAMINATION SURVEY

FINAL TECHNICAL PLAN
DECEMBER 1987
CONTRACT NUMBER DAAK11-84-D-0016
TASK NUMBER 6



ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
HARDING LAWSON ASSOCIATES MIDWEST RESEARCH INSTITUTE

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PREPARED FOR

US ARMY
PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

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THIS FINAL TECHNICAL PLAN DESCRIBES THE WORK TO BE UNDERTAKEN TO PROVIDE TECHNICAL SERVICES NECESSARY TO CONDUCT A PHASE I SURVEY OF SECTIONS 26 AND 35. THE OBJECTIVE OF TASK 6 IS TO OBTAIN THE SEMIQUANTITATIVE CHEMICAL DATA FROM EACH SITE SUFFICIENT TO ALLOW DETERMINATION OF SITE GEOMETRY, CONTAMINANTS PRESENT, AND DESIGN OF THE PHASE II PROGRAM.

SECTIONS OF THIS REPORT DETAIL INFORMATION ON THE FOLLOWING: FIELD SAMPLING, GEOPHYSICAL INVESTIGATION, CHEMICAL ANALYSIS, QUALITY CONTROL, HEALTH AND SAFETY, DATA COMPILATION AND MANAGEMENT, AND CONTAMINATION ASSESSMENT.

APPENDIX A CONTAINS A LETTER TECHNICAL PLAN FOR ADDITIONAL BASIN F SAMPLING.

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# LITIGATION TECHNICAL SUPPORT AND SERVICES

**Rocky Mountain Arsenal**

**Sections 26 and 35 Phase I Contamination Survey**



**Final Technical Plan**
**December 1987**
**Contract Number DAAK11-84-D-0016**
**Task Number 6 (Sections 26 and 35)**

**PREPARED BY**

**ENVIRONMENTAL SCIENCE & ENGINEERING, INC.**
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(Prepared under Task 19)

**PREPARED FOR**

**U.S. ARMY PROGRAM MANAGER'S OFFICE FOR ROCKY MOUNTAIN ARSENAL**

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# LIST OF ACRONYMS AND ABBREVIATIONS
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| | |
|---|---|
| AA | Atomic Absorption |
| AR | Army Regulation |
| A.S.P. | Certified Photogrammetrist |
| BCHD | bicycloheptadiene |
| °C | degrees Centrigrade |
| CFI | Colorado Fuel and Iron Corporation |
| cm | centimeters |
| COR | Contracting Officer's Representative |
| CPMS | p-chloropenylmethyl sulfide |
| CPMSO | p-chlorophenylmethyl sulfoxide |
| $CPMSO_2$ | p-chlorophenylmethyl sulfone |
| DBCP | dibromochloropropane |
| DCPD | dicyclopentadiene |
| DIMP | diisopropylmethyl phosphonate |
| DMMP | dimethylmethyl phosphonate |
| EPA | Environmental Protection Agency |
| ESE | Environmental Science and Engineering, Inc. |
| °F | degrees Fahrenheit |
| ft | feet |
| $ft^2$ | square feet |
| GC | gas chromatography |
| GC/MS | gas chromatography/mass spectrometry |
| HLA | Harding Lawson Associates |
| ICAP | inductively coupled argon plasma |

**LIST OF ACRONYMS AND ABBREVIATIONS**
**(Continued, Page 2 of 2)**

| | |
|---|---|
| in | inches |
| in/yr | inches per year |
| mph | miles per hour |
| MRI | Midwest Research Institute |
| OSO | Onsite Safety Officer |
| OSHA | Occupational Safety and Health Act |
| OVA | organic vapor analyzer |
| PID | photoionization detector |
| ppb | parts per billion |
| PPDDE | dichlorodiphenylethane |
| PPDDT | dichlorodiphenyltrichloroethane |
| ppm | parts per million |
| QA | Quality Assurance |
| QC | Quality Control |
| RIC | Rocky Mountain Arsenal Resource Information Center |
| RMA | Rocky Mountain Arsenal |
| Shell | Shell Chemical Company |
| µg/g | micrograms/gram |
| USAEHA | U.S. Army Environmental Hygiene Agency |
| USATHAMA | U.S. Army Toxic and Hazardous Materials Agency |
| USGS | U.S. Geological Survey |
| UXO | unexploded ordnance |

# 1.0 INTRODUCTION

## 1.1 DESCRIPTION OF THE RMA PROBLEM: SECTIONS 26 AND 35

The Rocky Mountain Arsenal (RMA) occupies over 17,000 acres (27 square miles) northeast of Denver, Colorado. Sections 26 and 35 are located in the northwest quadrant of the site. RMA is immediately south of the city of Henderson, Colorado and directly east of Commerce City, Colorado in western Adams County (Figure 1.1-1). The South Platte River flows parallel to the northwest boundary and is less than 2 miles from RMA. The Arsenal was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982. A detailed discussion concerning the overall RMA problems is presented in the Task 1 Technical Plan.

Sections 26 and 35 contain Basins B, C, D, E, and F which were used for storage of industrial wastes and wastewater generated on RMA. Basins B, C, D, and E are unlined and were used to store the overflow from Basin A during the period from 1953 to 1957. The overflow from Basin A occurred when its capacity was exceeded as a result of wastewater from the GB facility and the South Plants facilities being discharged into the basin. Because of a civil suit which charged that Basin A was polluting the ground water, Basin F (an asphalt lined reservoir) was constructed in early 1957. Basin F received all the industrial wastes and wastewaters generated from 1957 to 1982.

In addition to the basins there are several unlined drainage ditches and chemical and sanitary sewer lines located in Sections 26 and 35. The drainage ditches transported the overflow from Basin A to the other unlined basins. The chemical sewers carried industrial wastes and wastewaters from the manufacturing facilities to Basin F, and from Basin F to the deep well disposal facility.

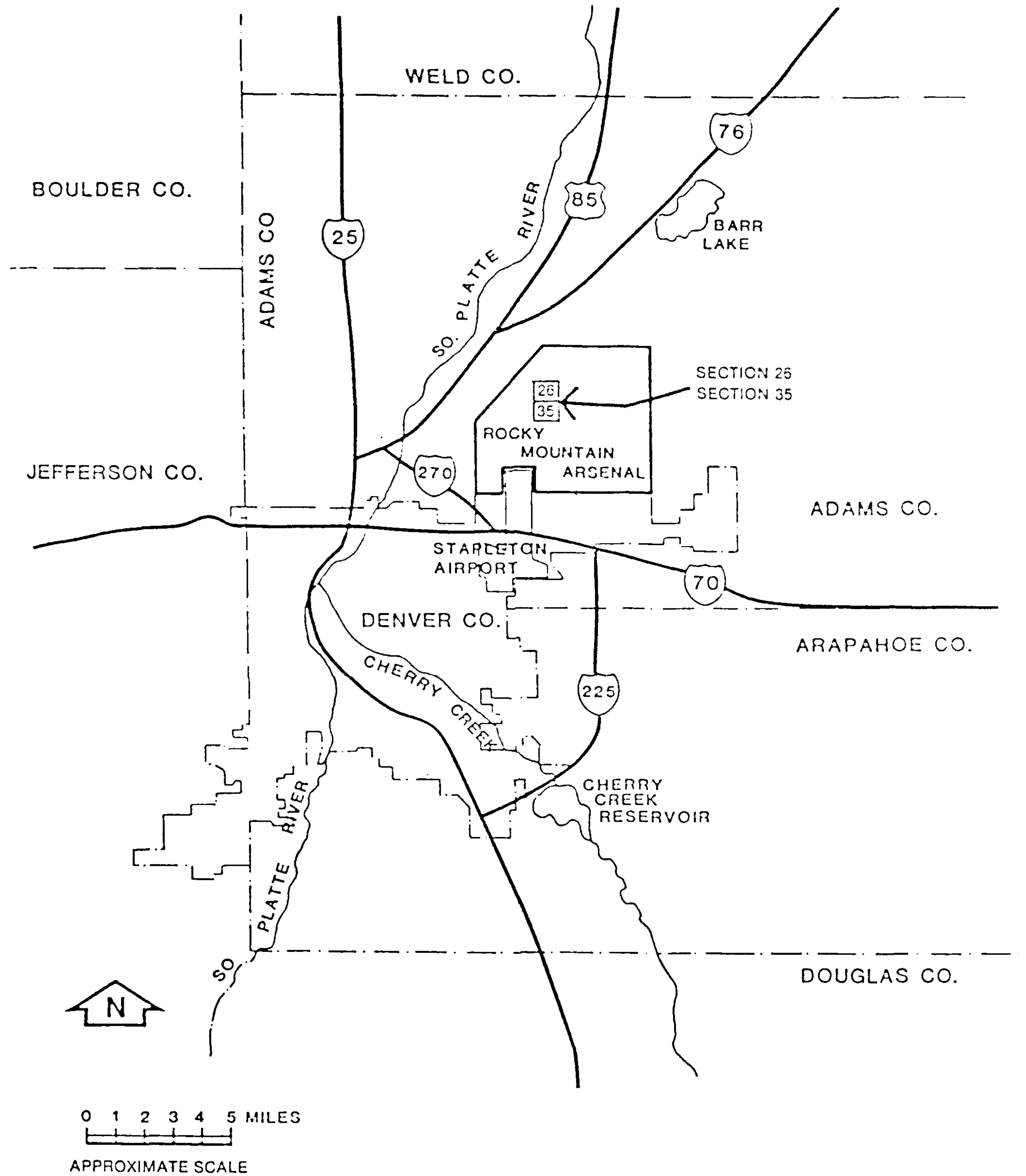


Figure 1.1-1

SITE LOCATION MAP

SOURCE: HARDING LAWSON ASSOCIATES

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**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

### 1.1.1 CONTAMINANT SITES

Previous studies and in·estigations performed in Sections 26 and 35 have yielded 19 specific contaminant sites. These sites are listed in Table 1.1-1. Background information concerning Sites 26-2, 26-10, 35-5, 35-8, and 35-9 has allowed Program Manager's Office (PMO) at RMA to classify these areas as non-source areas for the purpose of this study. Also, based on background information for each specific site, PMO-RMA has decided whether specific sites are most likely the result of previous Army activities or if the specific site has high probability of being a result of Shell or joint Shell/Army activities. All the sites are shown in Figures 1.1-2 and 1.1-3. This task addresses those sites which are most likely to be the result of Shell or Shell/Army activities.

Table 1.1-1 lists all 19 original contaminant sites, disposal activities, and the status of the current investigation at each site. An intensive investigation has been postponed for Sites 35-6, and 35-7. PMO-RMA has decided these sites will be investigated during performance of a subsequent task which is scheduled to be initiated in December 1985. Also, as a result of PMO-RMA budget constraints, investigation of areas suspected of contamination that were not part of the original scope-of-work for this task will be performed in a subsequent task. These sites include Sites 26-9, 35-2, and a part of Site 36-4. Sites 26-9 and 35-2, chemical sewer lines have been excavated and are stored in Basin F. However, this technical plan presents all the background information and proposed investigation for these sites.

The investigation of Site 26-1 has been divided into two parts: (1) closure of the deep disposal well, and (2) investigation of the chemical sewers associated with the deep well. RMA personnel and/or their contractor will perform the closure activities. Investigation of the chemical sewers will coincide with excavation during closure and will be performed during Task 6 or 14 as scheduling allows.

Table 1.1-1. Sections 26 and 35 Contaminant Sites

| Site | Site Activity | Alterations in Site Investigations |
|---|---|---|
| 26-1 | Deep Disposal Well | Chemical sewers may be investigated under a later task. The deep well investigated by RMA. |
| 26-2 | TX Production Area | Investigated as a non-source |
| 26-3 | Basin C | |
| 26-4 | Basin D | |
| 26-5 | Basin E | |
| 26-6 | Basin F | |
| 26-7 | Basin B-C Drainage | |
| 26-8 | Sanitary Sewer | Will not be investigated |
| 26-9 | Chemical Sewer | Task 14 |
| 26-10 | TX Irrigation Pond | Investigated as a non-source |
| 35-1 | Sanitary Sewer | Will not be investigated |
| 35-2 | Chemical Sewer | Task 14 |
| 35-3 | Basin B | |
| 35-4 | Basin A-B-C Drainage | |
| 35-5 | Ground Disturbance | Investigated as a non-source |
| 35-6 | Munitions Test Area | Task 14 |
| 35-7 | Firing Range | Task 14 |
| 35-8 | Storage Area | Investigated as a non-source |
| 35-9 | Caustic Holding Basin | Investigated as a non-source |

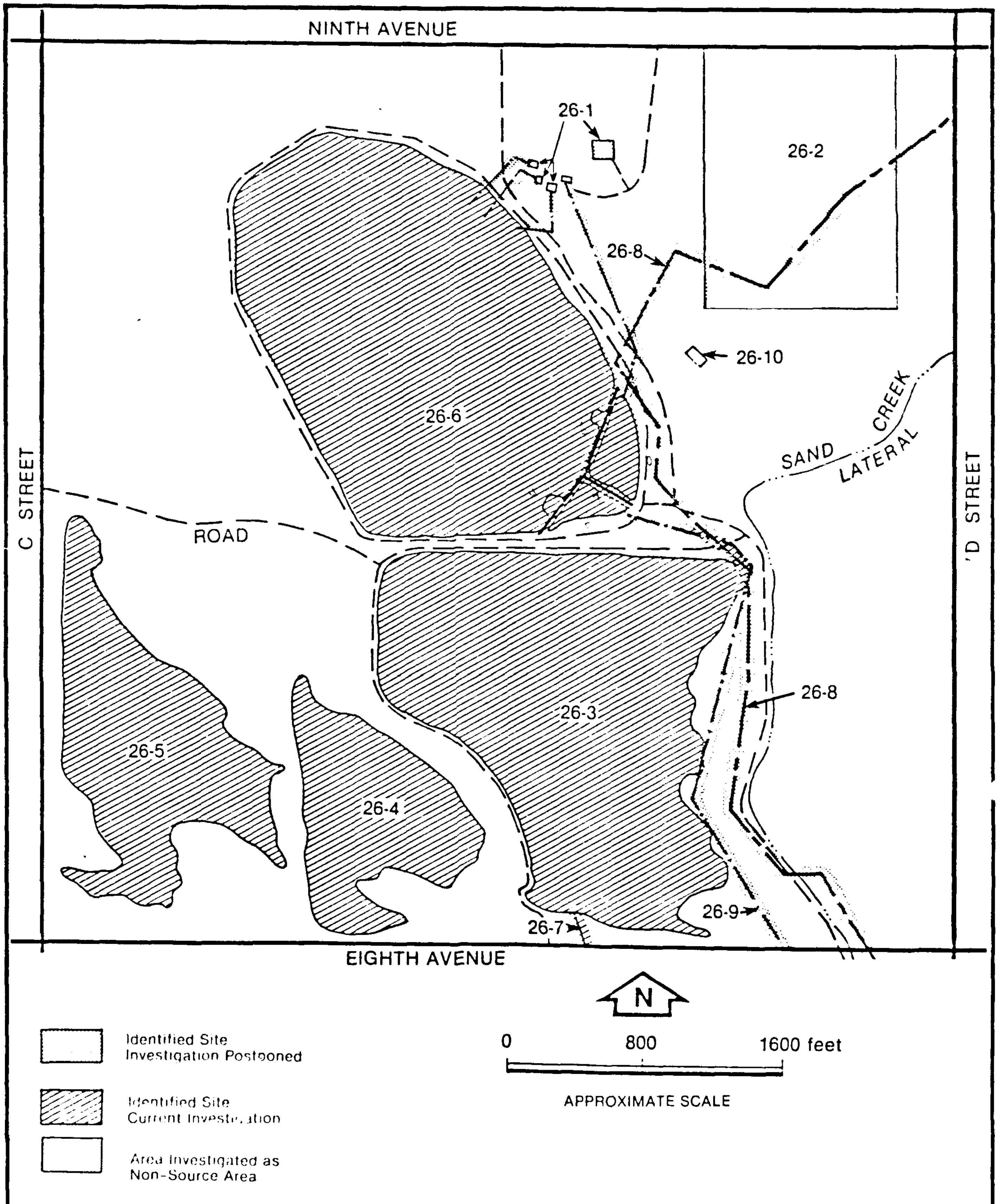


Figure 1.1-2
SITE LOCATION MAP
SITES 26-1 THROUGH 26-9
ROCKY MOUNTAIN ARSENAL, SECTION 26

SOURCE: HARDING LAWSON ASSOCIATES REVISION A 8/9/85

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U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

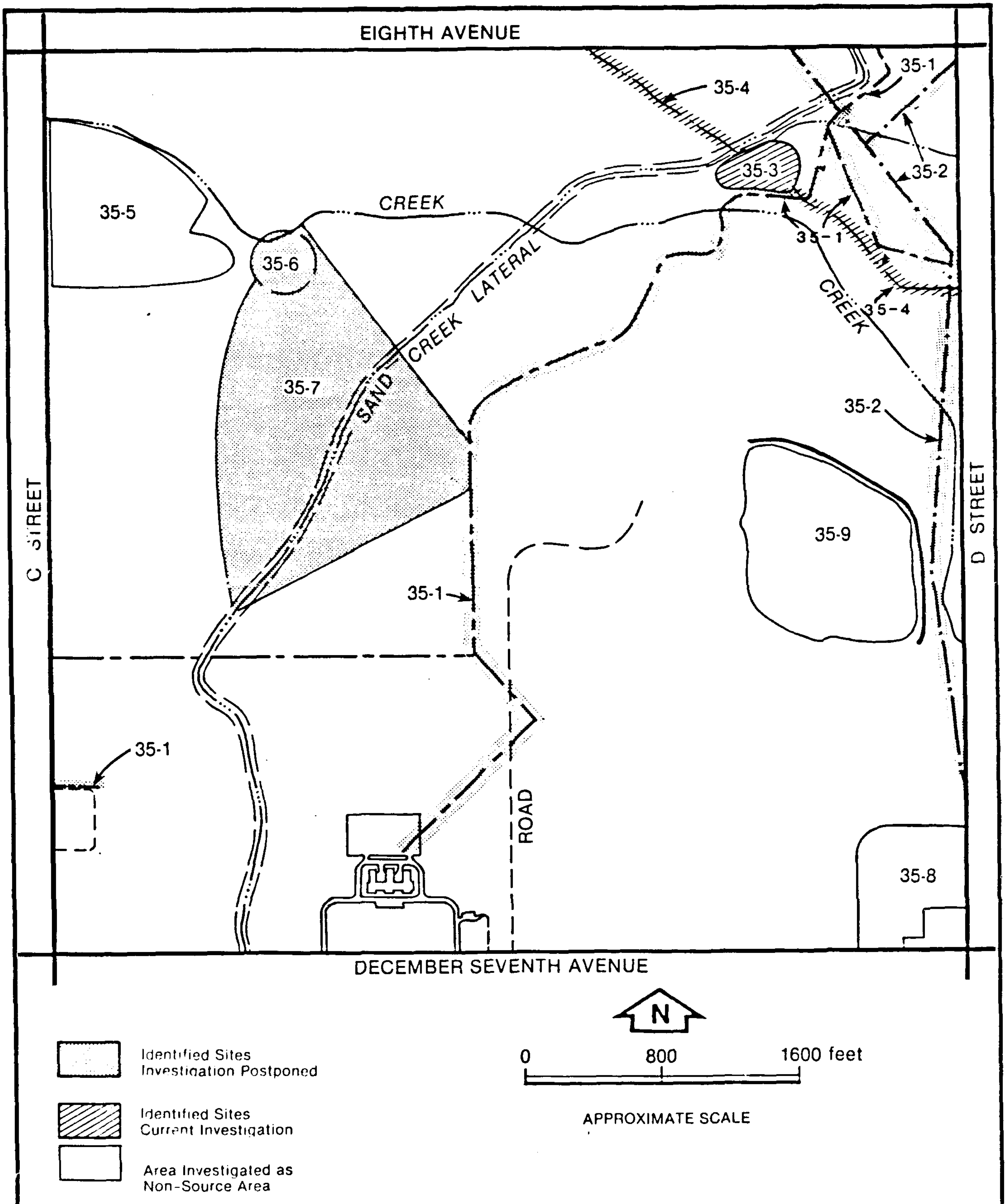


Figure 1.1-3
SITE LOCATION MAP
SITES 35-1 THROUGH 35-9
ROCKY MOUNTAIN ARSENAL, SECTION 35
SOURCE: HARDING LAWSON ASSOCIATES REVISION A, 8/9/85

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During preparation of this technical plan and review of associated RMA documentation, additional areas suspected of disposal activity not contained within site boundaries shown in Figures 1.1-2 and 1.1-3 were identified. The additional areas suspected of disposal activity consist of drainage ditches between basins and extensions of the chemical sewer located in Section 35 and for the most part are relatively small in size. In this case, site boundaries and their associated areal extents have been modified. Sites which have had boundary modifications are designated as follows: 26-3, 26-4, 35-2, and 35-4.

Figures 1.1-4 and 1.1-5 are maps of Sections 26 and 35 which indicate site boundaries as they will be investigated during this program. The base map site boundaries have taken into account all program alterations summarized in Table 1.1-1. Modification of site boundaries also include additional site areas. The contaminant sites of Sections 26 and 35 to be investigated under this task can be categorized by suspected use as follows:

| Site Category | Site to be Investigated |
|---|---|
| Lined/Unlined Basins | 26-3, 26-4, 26-5, 26-6, 35-3 |
| Open Drainage Ditch | 26-7, 35-4 |

The lined/unlined basins are Basins B, C, D, E, and F. The drainage ditches, include an extension of Site 36-8S and the main drainages from Basins A, B, and C.

### 1.1.2 GEOLOGY/SOILS

The geologic conditions underlying Sections 26 and 35 are relatively well defined as a result of the construction of numerous boreholes and cross sections. Many of the cross sections and boring logs are available from the Rocky Mountain Arsenal Resource Information Center (RIC).

The surficial geology consists of alluvial material over most of Sections 26 and 35. The alluvial deposits consist of interbedded silty clay,

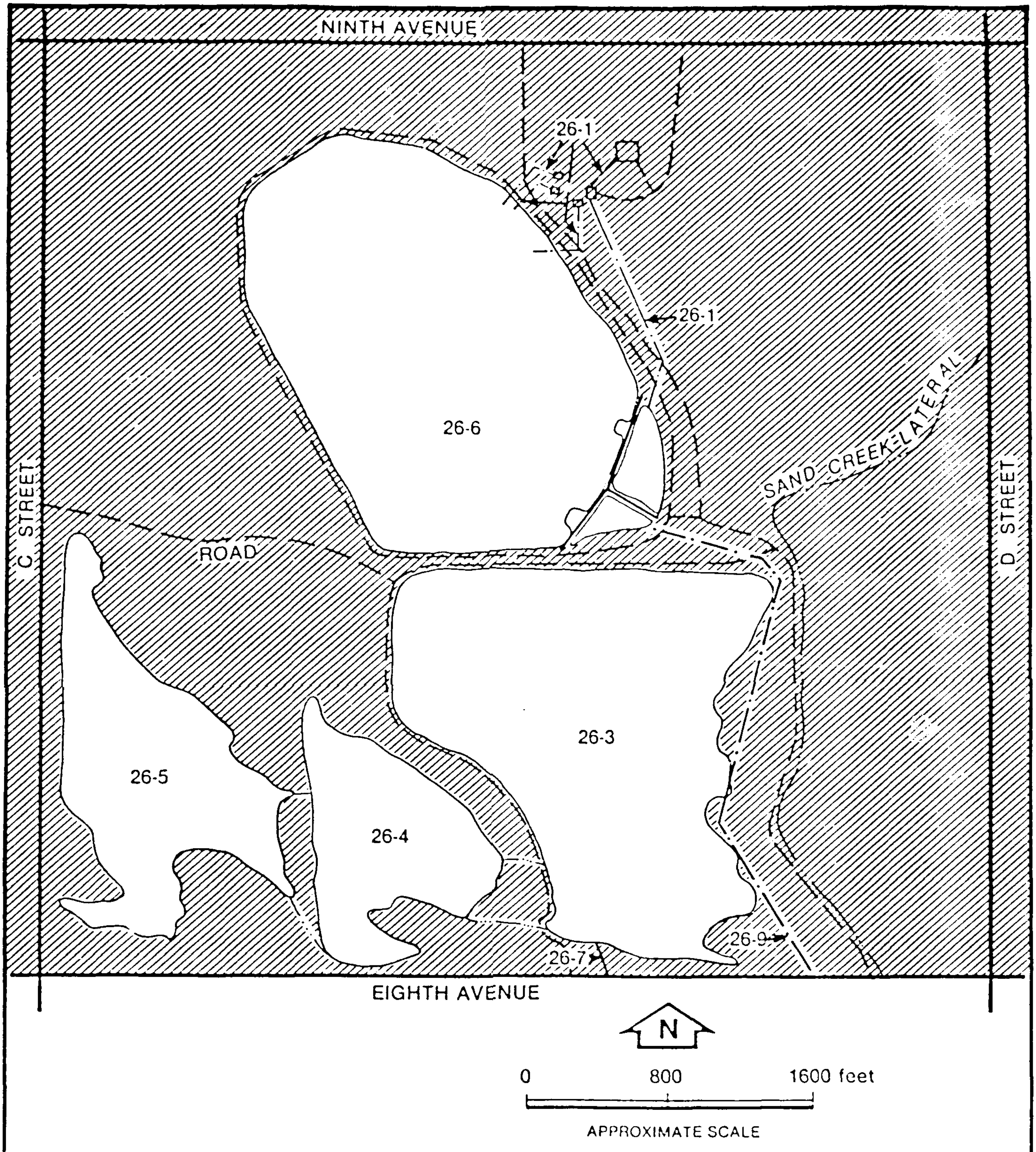


Figure 1.1-4
REVISED SITE LOCATION MAP
SHELL OR SHELL/ARMY SITE
SITES 26-3 THROUGH 26-12
RMA, SECTION 26

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**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

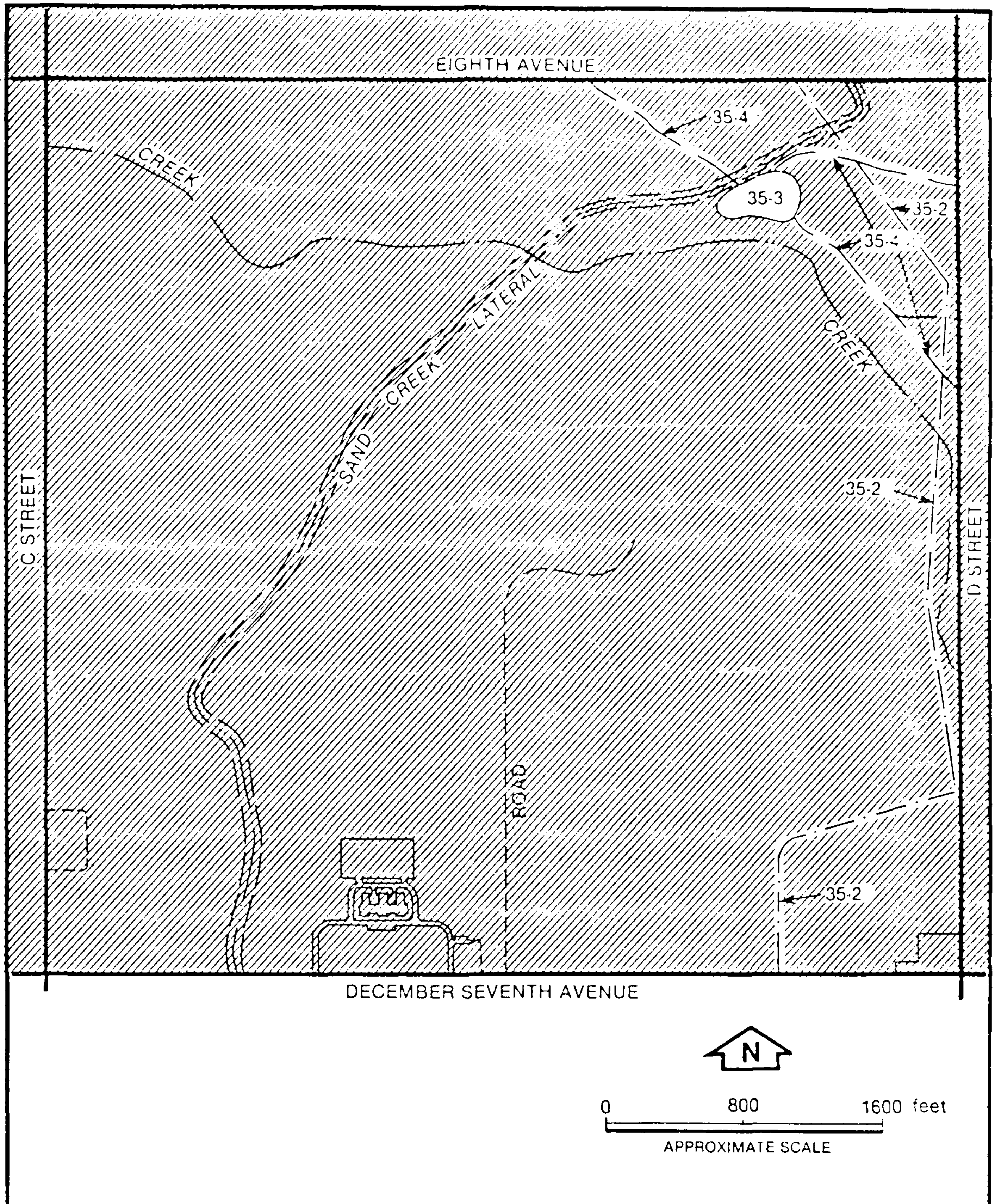


Figure 1.1-5
REVISED SITE LOCATION MAP
SHELL OR SHELL/ARMY SITE
SITES 35-2 THROUGH 35-12
RMA, SECTION 35

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

silt, sand, and gravel. In most areas the alluvium is covered by windblown silt. In Section 26, the thickness of the alluvium varies from 10 to 50 ft with thickest alluvium beneath Basin F. The alluvium varies in thickness from 20 to 40 ft in Section 35.

The soils present in Section 26 consist of the following major soil types: Ascalon sandy loam, Platner clay loam, Truckton loamy sand, and Weld loam (Sampson and Baber, 1974). The predominant soil types are Ascalon sandy loam and Truckton loamy sand.

Section 35 soils are predominantely Ascalon sandy loam and Truckton loamy sand. A small outcropping of the Denver Formation (clay-shale) is in the center of Section 35.

Ascalon sandy loam soil is formed on well-drained, nearly level to moderately sloping surfaces. The soil is a brown sandy loam which becomes progressively more clacareous with depth. Such soil absorbs water at a moderate to rapid rate, and permeability is moderate.

Platner clay loam forms on old alluvium surfaces that are level to gently sloping. Such soil is comprised of grayish-brown clays and clay loams to depths of 30 inches. Below this depth, the color is paler and the soil becomes sandy and more calcareous. This soil absorbs water slowly, and permeability is low.

Truckton sandy loam is formed on well-drained gently to strongly sloping surfaces. The soil absorbs water at a moderate to rapid rate, and permeability is moderate to rapid. The erosion hazard of this soil is moderate to severe.

Weld loam is found on well-drained very gently sloping surfaces. This soil absorbs water at a moderate rate and permeability is slow to moderate. Erosion hazard is moderate.

Beneath the alluvium lies the Denver Formation. Structural contour maps of the top of the Denver Formation for Sections 26 and 35 are presented

as Figures 1.1-6 and 1.1-7. The Denver Formation is a cyclic deltaic deposit consisting of interbedded silt, clay, and sandy units. The interpretation of the contact between the alluvial material and Denver Formation has changed during the course of RMA investigations based on differing classification of core samples. Not all geologic maps and cross sections are consistent. The upper portions of the Denver contain volcaniclastics, a thick sequence of clay shale with interbedded lenses of clay, sand, and lignite. Additionally, channel-sand deposits also occur. The lower portion of the Denver contains a discontinuous lignite seam, a semi-continuous sand unit, a clay shale, and channel-sand deposits. Beneath RMA, the Denver Formation ranges in thickness from 240 to 450 ft.

### 1.1.3 HYDROGEOLOGY AND GROUND WATER QUALITY

Shallow ground water beneath Sections 26 and 35 is contained in the two geologic units discussed in Section 1.1.2. The alluvial aquifer is unconfined while the Denver Formation aquifer is considered to be semi-confined in the upper zones and confined in the lower zones. Faults may be providing a hydraulic connection between the alluvial and Denver aquifers. However, May (1982, RIC#82295R01) states that aquifer pumping tests do not show that these faults significantly affect the local ground water flow regime. Ground water contour maps for Sections 26 and 35 are presented in Figures 1.1-8 and 1.1-9.

### 1.1.4 SURFACE WATER HYDROLOGY AND WATER QUALITY

Surface water features within Sections 26 and 35 include the following:

- o Basins B (35-3), C (26-3), D (26-4), E (26-5), F (26-6) and the caustic holding basin (35-9).
- o The Sand Creek Lateral which carries runoff from the South Plants area in a northeasterly direction across Section 35 and up the eastern third of Section 26.
- o Several drainage ditches that are extensions of drainages from Section 36. These include Site 35-4, and an extension of Site 36-8C which transverses Section 35 from east to west. Ditch Site 35-4 carried fluids from the Basin A neck area to Basins B and C.

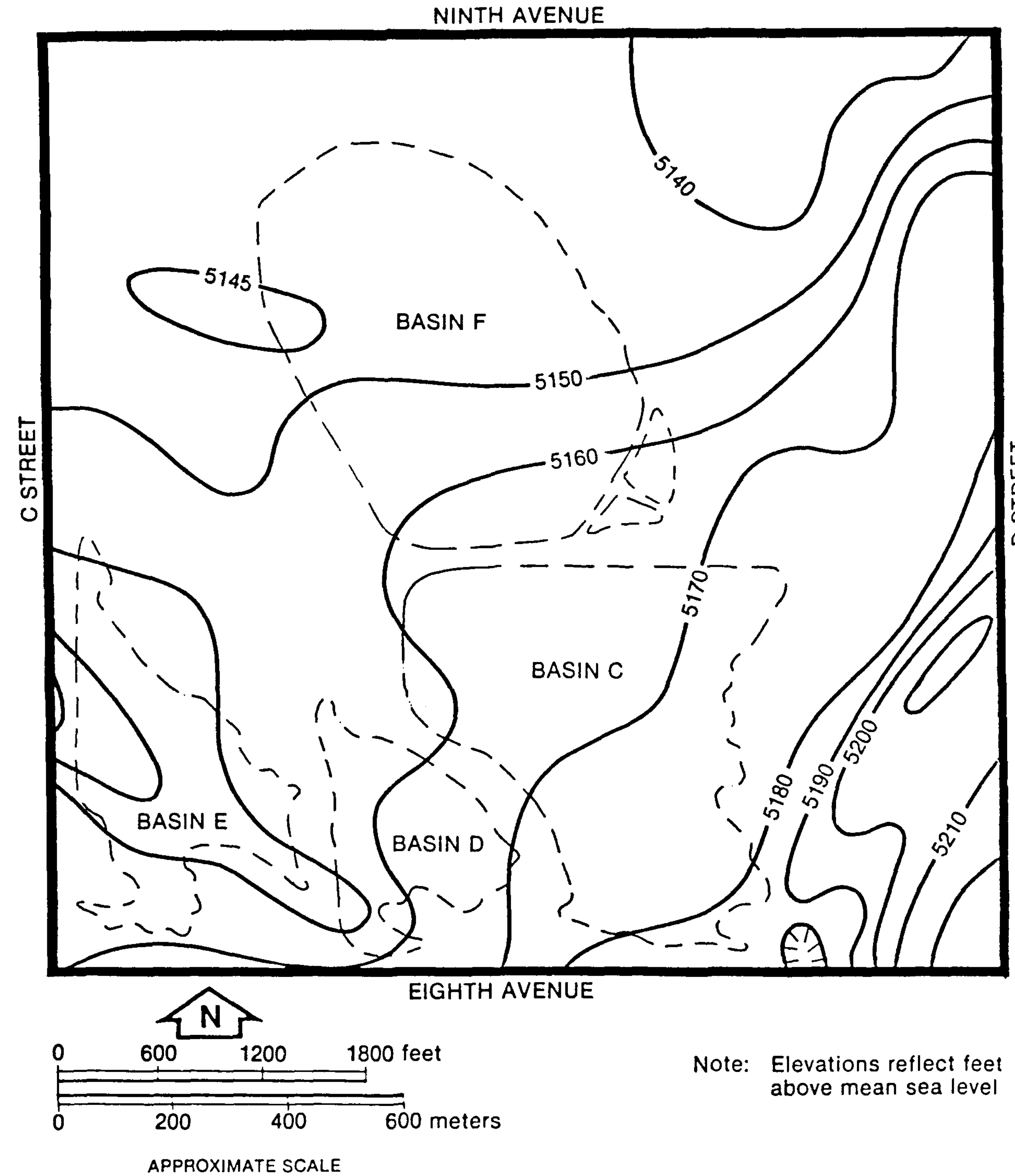


Figure 1.1-6
TOP OF THE DENVER FORMATION:
ROCKY MOUNTAIN ARSENAL, SECTION 26

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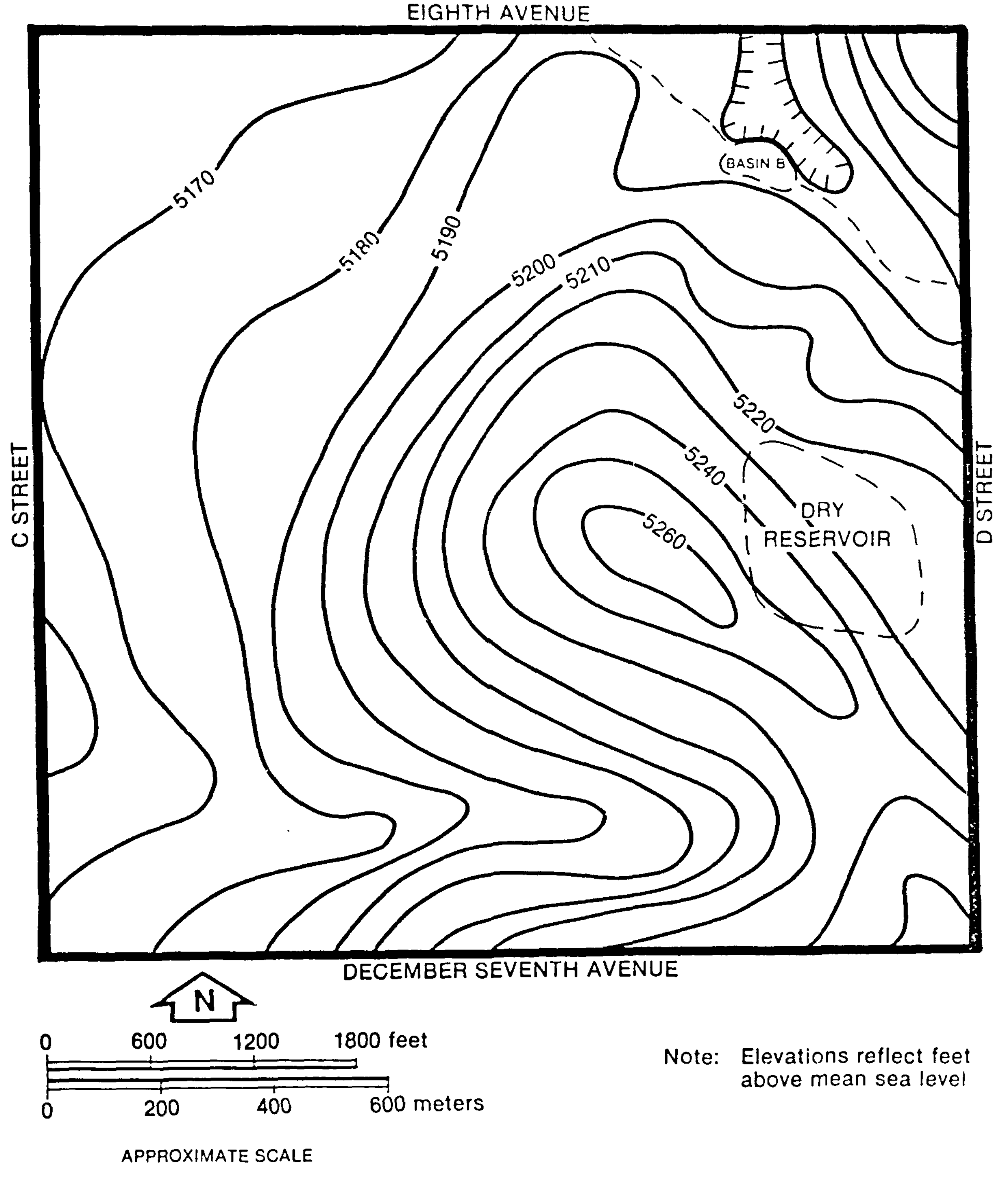
**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**




Note: Elevations reflect feet above mean sea level

Figure 1.1-7
TOP OF THE DENVER FORMATION;
ROCKY MOUNTAIN ARSENAL, SECTION 35

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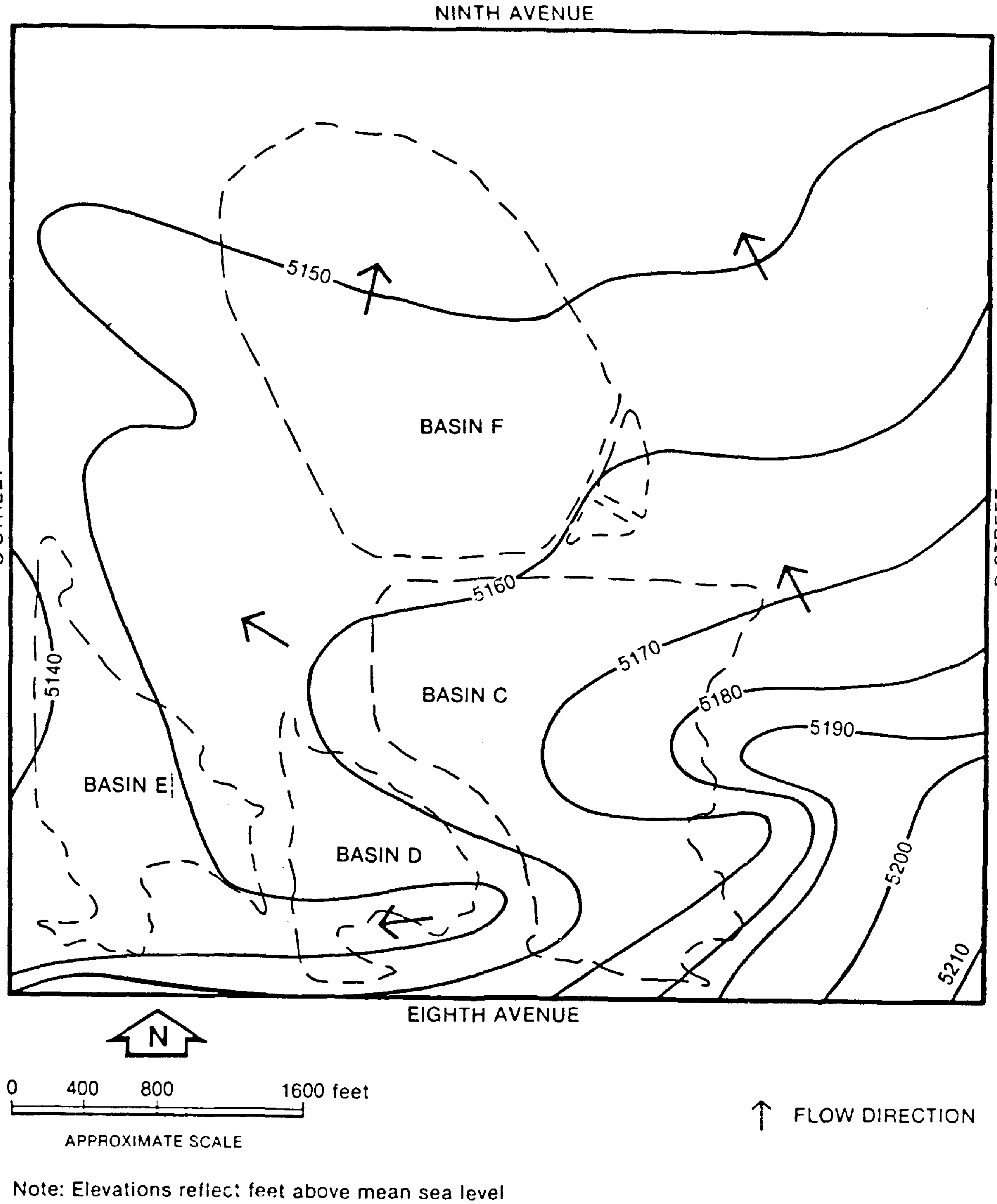


Note: Elevations reflect feet above mean sea level

Figure 1.1-8
GROUND WATER CONTOUR MAP
ROCKY MOUNTAIN ARSENAL, SECTION 26

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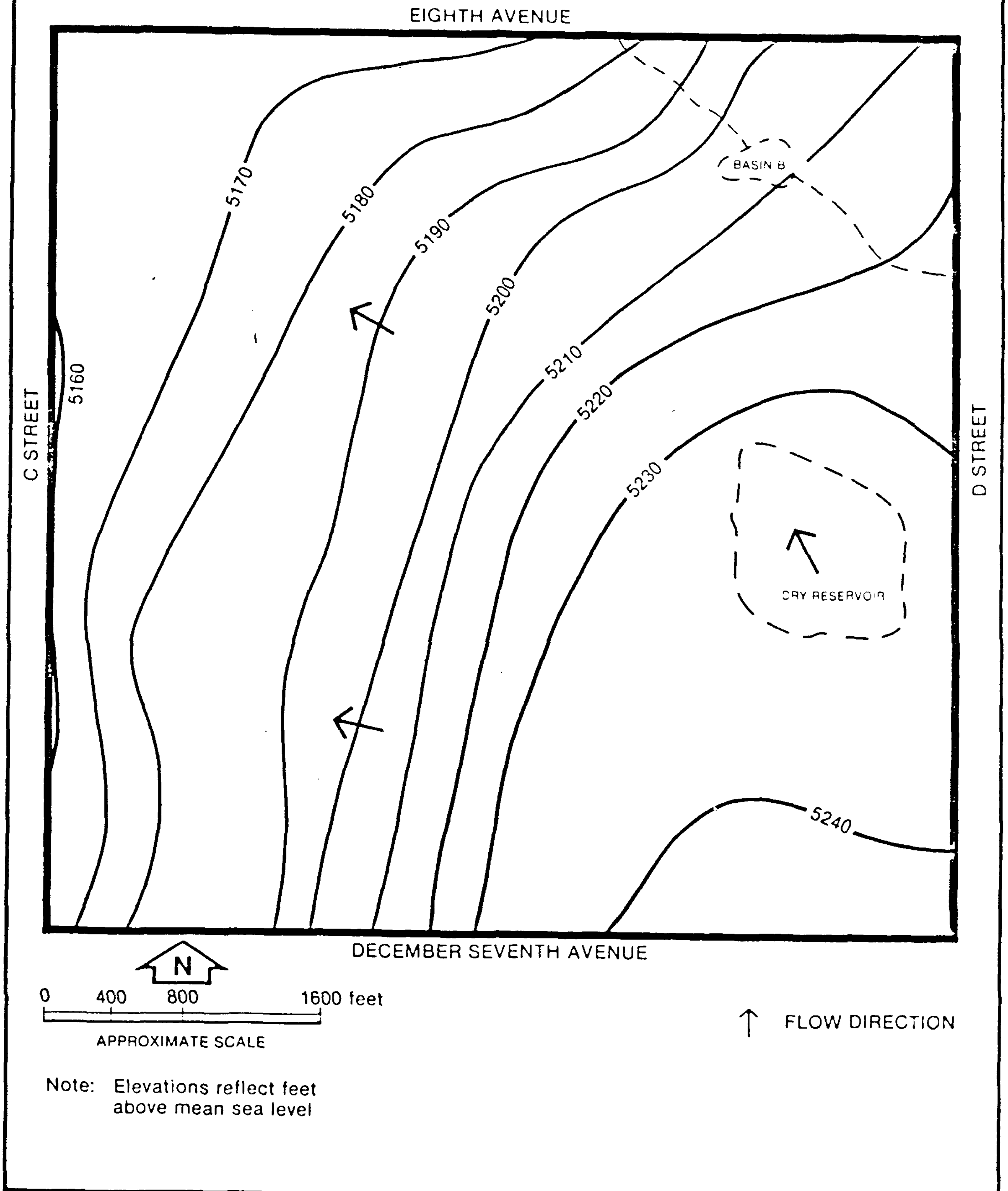
**Aberdeen Proving Ground, Maryland**




| | |
|---|---|
| Figure 1.1-9<br>GROUND WATER CONTOUR MAP<br>ROCKY MOUNTAIN ARSENAL, SECTION 35 | Prepared for:<br>U.S. Army Program Manager's Office<br>For Rocky Mountain Arsenal<br>Aberdeen Proving Ground, Maryland |

Topographic maps of Sections 26 and 35 are presented as Figures 1.1-10 and 1.1-11. These maps indicate the direction of surface water flow for both sections. Evaporation and infiltration keep the unlined basins relatively dry during late spring and summer. At the time of the site reconnaissance (June 1985), there were two distinct areas of ponding in Basin F (a lined reservoir). The ponded liquid appeared to be mixtures of rainfall and residual waste materials.

### 1.1.5 CLIMATIC CONDITIONS

The RMA area is generally classified as mid-latitude semi-arid. This indicates an area with hot summers, cold winters, and relatively light rainfall. Mean maximum temperatures range from 43 degrees Fahrenheit (°F) in January to 88°F in July. The mean minimum temperatures are 16°F in January and 59°F in July. Precipitation in the general region is approximately 12 to 16 inches per year (in/yr) with approximately 80 percent falling between April 1 and September 30. Snow and sleet usually occur from September to May with the heaviest snowfall in March and possible trace accumulations as late as June. Thunderstorms occur frequently in the region. They are generally accompanied by heavy showers, severe gusty winds, and frequent thunder and lightning with occasional hail. There are approximately 93.1 days per year with a cloud cover of 30 percent or less. Early morning inversions over the Denver Metropolitan Area are common, but they rarely persist through the day. This prevents mixing and causes accumulation of pollutants.

The prevailing winds at RMA are from the south and south-southwest, paralleling the foothills west of Denver. Occasional winds are also out of the north-northwest, north, and east. Wind speeds average about 9 miles per hour (mph) annually. The windy months are March and April, with gusts as high as 65 mph. These months come immediately after the driest months of the year (November through February) and have the highest potential for dust storms.

The Denver Metropolitan Area has experienced chronic air quality problems in recent years. During stagnant and/or inversion conditions, ozone and carbon monoxide concentrations sometimes create extremely poor air

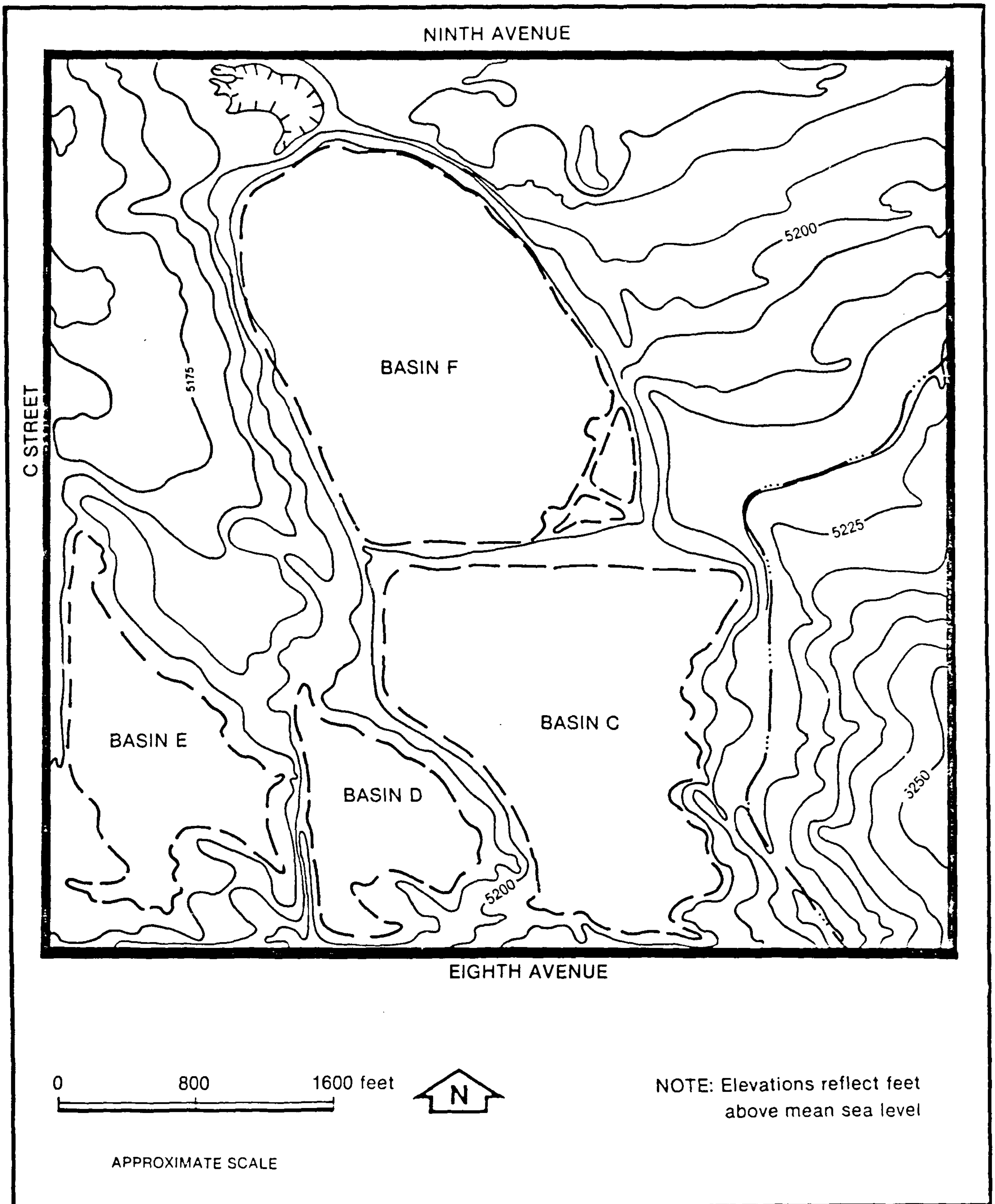



Figure 1.1-10
TOPOGRAPHIC MAP
ROCKY MOUNTAIN ARSENAL, SECTION 26

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For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

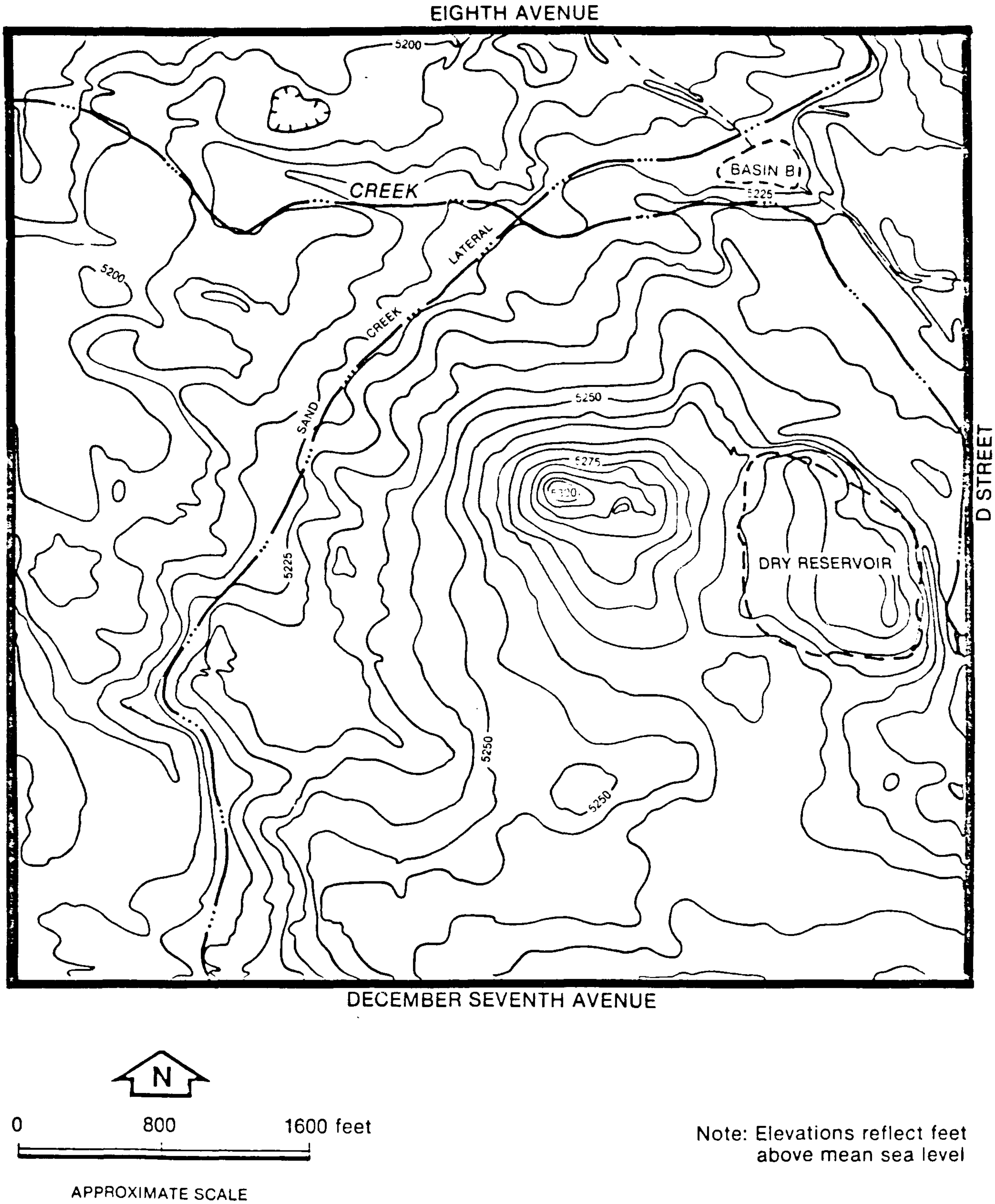



Figure 1.1-11
TOPOGRAPHIC MAP
ROCKY MOUNTAIN ARSENAL, SECTION 35

**Prepared for:**
**U.S. Army Program Manager's Office For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

quality. This problem has generally been associated with motor vehicles, and the area impacted includes RMA.

RMA's potential influence on air quality includes windborne migration of contaminant-bearing particulates from dry waste basins and volatile organic emissions from Basin F. Because of these concerns, the U.S. Army Environmental Hygiene Agency (USAEHA) was requested to examine potential air quality problems and recommend appropriate precautions. A suspended particulate study of the dry basins was conducted in 1981 by USAEHA to evaluate the health hazard posed by low levels of fugitive dust. The contaminants studied were arsenic, mercury, cadmium, copper, lead, aldrin, dieldrin, and endrin. Concentrations of the various contaminants monitored in the fugitive dust were considered not to pose a significant hazard to members of the general population around RMA or to individuals occupationally exposed to windblown dust emanating from disposal basins at RMA (Gusewick and Deeter, 1982, RIC#83192R02; Bond and Thomasino, 1981, RIC#81293R04). Future air monitoring will be conducted under Task 17.

### 1.1.6 BIOTA

A significant portion of Section 26 and to a lesser degree Section 35 have been disturbed by disposal activities. Specifically these areas include Basins B, C, D, E, and F and several manmade drainage ditches and sewer systems which traverse Sections 26 and 35. A vegetation and animal life study was performed by Anderson and Kolmer (1977, RIC#81295R07) which describes the primary vegetation as successional. This denotes recently disturbed material with dominant species being wheatgrass, prickly lettuce, and western ragweed. The central portion of Section 35 is termed mid- to late-successional with dominant species including sand dropseed, red threeawn, crested wheatgrass, and blue grama. This study also summarized preliminary biological work by listing invertebrates, amphibians, reptiles, birds, and mammals which frequent this habitat. Future biota studies will be conducted under Task 9.

## 1.2 SUMMARY OF TECHNICAL APPROACH

The primary purpose of this Phase I investigation for Sections 26 and 35 is to obtain geotechnical and geochemical data that will be used to evaluate and design a Draft Phase II Quantitative Investigations Program. To accomplish this objective, specific geochemical data must be compiled and evaluated for each contaminant site. This data must include determination of:

- Contaminants present;
- Lateral extent of contamination;
- Vertical extent of contamination;
- Site geometry;
- Site homogeneity; and
- Origin of specific contaminants.

To collect these data, the project team will perform numerous soil borings within Sections 26 and 35, collect soil samples, submit these samples for chemical analysis, and interpret the resulting data. To achieve maximum program efficiency, the investigation has been separated into Phase I and Phase II. Task 6 will contain only the Phase I investigation. Phase II will be performed under a subsequent task order.

The objective of Task 6 is to obtain the semiquantitative chemical data from each site sufficient to allow determination of approximate site geometry, contaminant compounds present, site responsibility and supply sufficient information to later design a Phase II program (Task 18). Phase I will use gas chromatography/mass spectrometry (GC/MS) and metal screening procedures to identify the types of compounds present at each site and the approximate areal and vertical extent of contamination. Phase I will also analyze a sufficient number of samples from all non-source and background areas of Sections 26 and 35 to ensure with a reasonable degree of certainty that these areas are free of significant contamination. During Task 6, borings will be constructed at each site. Twenty percent of these borings will be constructed to the water table. At sites where disposal or containment of liquids has occurred, the Phase I investigation will halt at the point of water table contact. Soils

collected from all Phase I borings will be submitted to the laboratory for semiquantitative scanning and select quantitative analyses for the same list of potential organic and inorganic contaminants as performed in Task 1.

Prior to any sample collection, all obtainable and relevant background data will be compiled and evaluated. Much of this subtask has been performed during preparation of this Technical Plan.

The support facility constructed for the Task 1 (Section 36) investigation will provide the project team with personnel and equipment decontamination services. This support facility will also be used for project team office space, materials storage, and working area. Establishment of a coordinate system for Sections 26 and 35 will be performed in order to determine exact locations of disposal sites.

Limited geophysical methods as determined appropriate by the Task 1 investigation will be used to determine if buried objects may be present at drill site locations. Soil sampling will be performed as described in Section 3.4 of this Technical Plan at locations specified in Section 3.3.

# 2.0 EVALUATION OF BACKGROUND DATA

## 2.1 DATA COMPILATION

Although a considerable effort has been made to review site specific background information for the Task 6 (Sections 26 and 35) investigation, the project team expects the gathering of pertinent data to be an ongoing process. A constant review of background data will be performed throughout the duration of the project.

### 2.1.1 INITIAL SITE RECONNAISSANCE

On June 7, 1985 several personnel from Harding Lawson Associates (HLA) and Environmental Science and Engineering, Inc. (ESE) performed a site reconnaissance of Sections 26 and 35. The purpose of the site reconnaissance was to validate mapped locations of contaminant sources, examine the spacial and physical relationship of known sources, and to identify additional potential sources. During the course of the site reconnaissance, all deviations from the RMA contaminant maps were noted.

For the most part areal extents of Basins B through F were found to be correctly mapped. However, several drainage ditches connecting these basins were not included in the confines of the respective basins. These areas have been subsequently added to the investigation.

### 2.1.2 LITERATURE REVIEW

The project team, during preparation of this Technical Plan has reviewed a number of documents detailing the location of Section 26 and 35 sites, their probable disposal history, and approximate areal extent. A bibliography of these references can be found in this plan. Particular attention has been paid to chemical compounds and hazards expected to be encountered at each site.

## 2.2 SECTIONS 26 AND 35: CONTAMINANT SITES

Within these two sections, at least 19 discrete potential sites have been identified. These sites were identified primarily by examination of aerial photographs and review of existing background

documents. These sites include a lined basin (Basin F), unlined basins, surface water drainages, chemical sewers, and open chemical drainages. Specific details for each site can be found in Section 3.3.1 of this Technical Plan.

# 3.0 GEOTECHNICAL PROGRAM

The primary purpose of the Task 6 geotechnical investigation is to identify contaminant compounds present and define the areal and vertical extent of soil contamination above the water table by performing a Phase I investigation in Sections 26 and 35. A list of the sites to be investigated and probable disposal use is presented as Table 1.1-1. Site locations are shown in Figures 1.1-4 and 1.1-5. The purpose of Task 6 is to obtain Phase I semiquantitative geotechnical and geochemical data which will provide a preliminary assessment of the extent of the contaminated zones and also information on the chemical compounds present at each site. Task 6 data will be provided as information for determination of Shell liability at the first hearing scheduled for January 1986. The Task 6 data will be used to develop the sampling program for Phase II. All drilling procedures, sample collection, sample preservation and handling procedures, as well as data recording procedures will be in accordance with USATHAMA Geotechnical Requirements (RMACCPMT, 1983, RIC#83326R01) as detailed in the Task 1 Technical Plan.

## 3.1 ESTABLISHMENT OF COORDINATE SYSTEM

To facilitate site and boring locations for the geotechnical program, a coordinate system will be established for Sections 26 and 35. This system will consist of a network of coordinate points located on 1,000 ft centers that can interface with the current USATHAMA database. The points will be marked with 4-ft-long wooden 4 by 4's placed firmly in the ground. Each point will be assigned a unique number using a system which is clearly distinct from that used for numbering the borings. Each reference number will be stamped on a metal tag affixed to its corresponding stake. After all the points are staked and numbered, their map coordinates and ground-surface elevations will be determined by a surveyor registered in the State of Colorado. The data will be compiled in tabular form and will include for each point, the reference number, the map coordinates, the ground surface elevation, and the measurement date. The reference data will be clearly stated. In addition, the lots formed by the coordinate system will each be assigned a unique number.

Horizontal and vertical surveys will be established within the site to control the mapping and to provide locations for geotechnical investigations. Horizontal control will be based on the Colorado State Plane Coordinate North Zone and vertical control will be based on Mean Sea Level of 1929.

Basic horizontal control for mapping will consist of electronic traverses originating and closing on stations of the U.S. Geological Survey (USGS) or National Geodetic Survey and conforming to second order standards of accuracy. Ties will be made from traverse stations to any apparent section corners or quarter corners found in Sections 26 and 35.

Vertical control will consist of elevations determined by spirit leveling to third order standards of accuracy. Elevation will be established for traverse stations or other suitable semipermanent points as well as for the photographic identities required for mapping.

Control for the geotechnical investigations will consist of coordinates and elevations determined for the 1,000-ft grid of points marked by wooden stakes. This network will be rayed in from the traverse stations using the HP3820 or equivalent theodolite/EDM, to conform to plus or minus 2 ft accuracy.

All surveys will be performed under the directions of a Land Surveyor registered in the State of Colorado. As weather conditions permit, black and white aerial photography will be obtained of the project area at a nominal negative scale of 1 inch equals 425 ft using a Wild RC-10 or equivalent precision mapping camera equipped with a high resolution-low distortion lens.

Aerial negatives will conform to accepted mapping specifications for scale, overlap, density, and image quality. Utilizing the aerial photography and ground control described above, orthophoto base maps with superimposed contours will be prepared.

Orthophoto negatives will be prepared directly at the final scale of 1 inch equals 200 ft, and contours will be plotted at 2-ft intervals with spot elevations shown to the nearest tenth of a foot where the contours are more than 4 inches apart at map scale.

All work will be performed under the direction of a Certified Photogrammetrist (A.S.P.) and will conform to National Map Accuracy Specifications. Maps generated by this task will be used to locate contaminant sites and borehole locations.

## 3.2 SURFACE GEOPHYSICS

Review of existing background data for Sections 26 and 35 have not resulted in identification of any information that suggests buried metal debris or unexploded ordnance (UXO) exist at the sites to be investigated under Task 6. However, Sites 35-6 (Munitions Test Ranges) and 35-7 (Firing Range), which will not be investigated under Task 6, have uncertain areal extents. In addition, several drums were observed in Basin C (Site 26-3). Although an extensive geophysical program is unnecessary for the Task 6 investigation, a method of locating buried metal objects in the immediate vicinity of a proposed borehole is necessary. Therefore, a minimal geophysical program is proposed with provisions to upgrade the investigation as appropriate.

The primary objective of the Task 6 geophysical program is to locate buried metal objects at proposed borehole locations. This will be accomplished by use of a metal detector which the Geophysical Test Program performed in Task 1 estimated was effective to depths of 2 ft. An area approximately 20 ft in diameter surrounding the borehole will be screened and the borehole location moved if necessary. If use of the metal detector results in the location of significant metallic debris in Sections 26 and 35 site areas then the geophysical program in that site will be upgraded to include use of the gradiometer methods employed in Section 36 (Task 1).

The proposed geophysical program in areas where significant metal debris may be found would include the set up of a 20-ft-square grid and

gradiometer transects run on 5-ft intervals. Following collection and compilation of data an IBM PC will be used to present gamma contours. The metal detector will then be utilized to discern if metal is at a depth of 2 to 5 ft or near surface (0 to 2 ft). The borehole location will be moved following interpretation of the generated geophysical data. All geophysical methods are described in detail in the Task 1 Technical Plan.

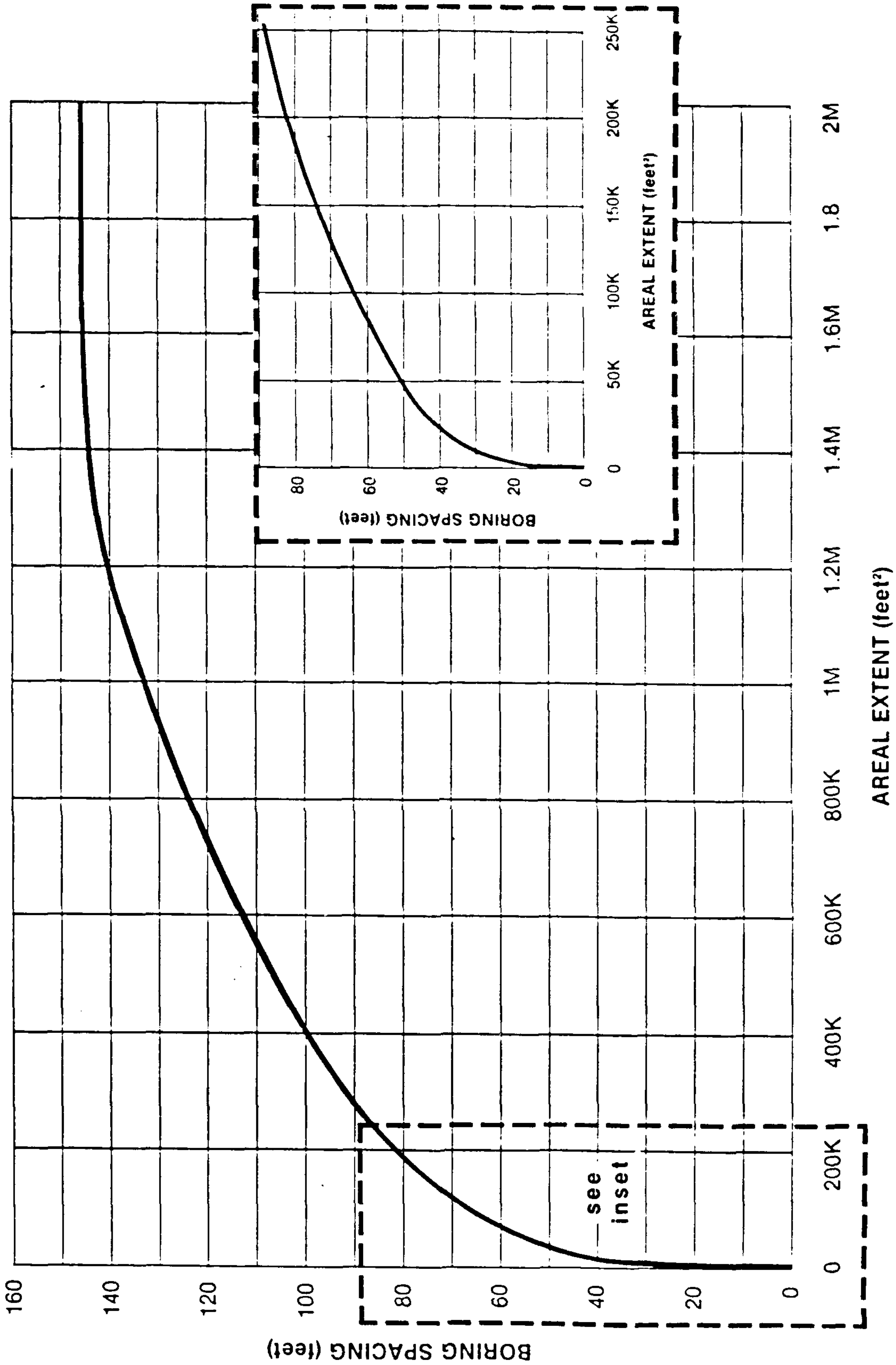
## 3.3 BORING PROGRAM STRATEGY

In order to designate an adequate number of borings to small sites areas and prevent large site areas from containing the majority of boring locations, a single grid spacing could not be selected for all contaminant sites. Therefore, a method for determining tighter boring spacings for small sites and wider boring spacings for large areas was devised. This method is based upon prior experience at contaminated sites, best professional judgement, and the following characteristics of each specific site:

- o Estimated areal extent of contamination.
- o Suspected contaminant compounds.
- o Past disposal practices.

Upon consideration of the above factors, Figure 3.3-1 was generated. This curve represents selected boring spacing for the total (Phase I and II) program as a function of the areal extent of contaminant sites. With an estimated areal extent for a specific site, the boring spacing was selected and rounded to the nearest 10 ft interval. For example, a contaminant site whose areal extent is 250,000 square feet ($ft^2$) yields a boring spacing of approximately 88 ft, which is rounded to 90 ft. This would result in 31 borings for this site. Phase I and Phase II borings will be arranged for each site in a uniform grid pattern to aid in statistical interpretation following completion of each phase.

All non-linear sites in Sections 26 and 35 were exposed to fluids of variable and complex composition, and therefore, all of these sites are considered complex. However, approximately 50 percent of the areal extent of Basin F is either not accessible or covered by water and cannot be sampled. The quantity of existing available information for Basin F




| Figure 3.3-1<br>BORING SPACINGS FOR SITES<br>BASED ON AREAL EXTENT<br>RMA, SECTIONS 35 AND 26<br>SOURCE: HARDING LAWSON ASSOCIATES | Prepared for:<br>U.S. Army Program Manager's Office<br>For Rocky Mountain Arsenal<br>Aberdeen Proving Ground, Maryland |
|---|---|

has resulted in a downgrading of the investigative boring spacing as calculated from Figure 3.3-1. The boring spacing for Basin F as determined by Figure 3.3-1, was multiplied by a factor of 1.25 and rounded to 190 ft.

Once the total number of Phase I and Phase II borings was calculated for these non-linear sites this number was multiplied by 30 percent for sites less than 1,000,000 $ft^2$ and 25 percent for sites in excess of 1,000,000 $ft^2$ for construction during Task 6 (Phase I). The remaining boreholes will be constructed during a subsequent task.

For linear sites such as drainage ditches and sewers, a different approach has been taken. Borings will be constructed at a 500-ft spacing for the length of each drainage ditch or sewer which contained contaminated fluids or had a high likelihood of containing such fluids. An example of this type of site is the drainage ditches between Basins A, B, C, D, and E.

In general, 20 percent of all Phase I borings within a site area will be constructed to the water table. These deep borings will be near the center of sites and will not go beyond the water table in order to reduce the potential for inducing ground water contamination. The remaining 80 percent of Phase I borings will be constructed to shallower depths within the unsaturated zone.

Large portions of RMA are considered to be non-source areas; however, some of these non-source areas are adjacent to known sites while other non-source areas are far from contaminant site boundaries. To provide adequate data to confirm that areas adjacent to known sites are free of significant contamination and to provide background information on large non-source areas, the following strategy was devised. Boring spacings for non-source areas are selected as 500 ft, 750 ft, or 1,000 ft dependent upon historical information. For non-source areas which are located in sections having a high percentage of contaminated area (Section 36), a boring spacing of 500 ft will be selected. For sections having a moderate percentage of contaminated areas, a boring spacing of

750 ft will be selected. For RMA sections which contain few or no known contaminant sites, a boring spacing of 1,000 ft will be selected. Figures 1.1-4 and 1.1-5 show that the most of Sections 26 and 35 are designated as non-source areas. These non-source areas, however, include a moderate percentage of contaminated area due to the proximity of large unlined and lined site basins. A boring spacing of 750 ft was, therefore, selected for all non-source areas in these two sections.

The non-source areas of Sections 26 and 35 contain several drainage ditches that could possibly contain contaminated soil. The boring spacing described previously does not adequately locate borings in these areas; therefore, borings will be placed in the drainage ditches at a boring spacing of 2,000 ft. This boring spacing will provide sufficient analytical data to confirm that these areas are non-source areas.

All borings in non-source areas will be constructed to 5 ft, but only a single composite soil sample will be submitted for chemical analysis from each boring. Samples will be composited from sample intervals of 0 to 1 ft and 4 to 5 ft in line with sampling intervals discussed in Section 3.4. As with borings in specific sites, these non-source area borings will be arranged in a regular grid pattern at locations shown in detail in Section 3.3.1.

The Phase I borings range in depth from 1 ft to the depth of the water table. Most borings at each site will be shallow. A small percentage of the borings will be drilled to the water table which in some areas may be up to 40 ft deep. The deep borings will be in areas where the contamination is expected to be deepest, generally near the site centers. Although a single deep boring may suffice for the small sites, the larger sites will require several deep borings. For all borings, depending on the designated depth, samples will be obtained from the following depths:

| | |
|---|---|
| 0.0-1.0 ft | 19.0-20.0 ft |
| 4.0-5.0 ft | 29.0-30.0 ft |
| 9.0-10.0 ft | 39.0-40.0 ft |
| 14.0-15.0 ft | |

Task 6 results will provide a list of contaminants present in each site, so that chemical analyses of Phase II samples can be individually tailored. Because the historical data regarding the types of contaminants present may be inaccurate or incomplete, all Phase I soil samples will be scanned for a wide variety of analytes. Chemical analyses performed for all Phase I samples will include a semi-quantitative gas chromatography/mass spectrometry (GC/MS) scan for volatile and extractable organic compounds and an inductively coupled argon plasma (ICAP) spectrophotometry scan for metals. In addition, these samples will be analyzed using quantitative methods for selected analytes which would not be detected by the above methods at the levels required. These methods include analyses for dicyclopentadiene (DCPD)/bicycloheptadiene (BCHD), arsenic, and mercury. A summary of the Phase I Chemical Analysis Program appears in Section 4.0. Because historical data suggest that volatile organic compounds may be present in the soil only at specific locations, all soil samples from sites thought to contain volatiles (35-3, 26-1, 26-3, 26-4, 26-5, and 26-6) will be analyzed by GC/MS for volatile organic compounds. In locations where the presence of volatile organic compounds is not expected, only 10 percent of the soil samples will be analyzed for volatile organic compounds. For all borings, except those located in Basin F, the samples collected from 0 to 1 ft will not be analyzed for volatile organic compounds. Specific details concerning the Analytical Chemistry Program are presented in Section 4.0.

### 3.3.1 SITE CONDITIONS AND SOIL BORING PROGRAM

As discussed in Section 1.0 of this Technical Plan, Sections 26 and 35 at RMA contain numerous potential contaminant sites. Table 3.3-1 and Figures 1.1-4 and 1.1-5 summarize the status of the Task 6 investigation with respect to these potential sites. In the process of data review, additional areas suspected of containing contaminant sites were identified. During this review there was no evidence that surety material would be present in either of these sections. This portion of

Table 3.3-1. Sections 26 and 35 Geotechnical Sampling Summary

| Site | Site Activity | Areal Extent ($ft^2$) | Length (ft) | Spacing | Number of Borings | Number of Samples |
|---|---|---|---|---|---|---|
| 26-1* | Deep Well Chemical Sewers | — | 2,600 | 200 | 13 | 13 |
| 26-3' | Basin C | 3,174,000 | — | 150 | 35 | 109 |
| 26-4' | Basin D | 877,000 | — | 130 | 16 | 50 |
| 26-5 | Basin E | 1,280,000 | — | 140 | 16 | 47 |
| 26-6 | Basin F | 4,051,000 | — | 190 | 14 | 47 |
| 26-7 | Basin B-C Drainage | — | 300 | 500 | 1 | 5 |
| 26-9* | Chemical Sewer | | | | | |
| | (Continuation of 36-20,35-2) | — | 3,300 | 500 | 7 | 7 |
| 26-U | Section 26 - Non-Source Area | 20,000,000 | — | 750 | 36 | 36 |
| | *Section 26 - Uncontaminated Ditches | — | 4,200 | 2,000 | 2 | 2 |
| 35-2'* | Chemical Sewer | | | | | |
| | (Continuation of 36-20, 26-9) | — | 6,700 | 500 | 13 | 13 |
| 35-3 | Basin B | 77,000 | — | 60 | 6 | 14 |
| 35-4' | Basin A-B-C Drainage | — | 2,500 | 500 | 5 | 12 |
| | *Additional Area | | 1,500 | 500 | 3 | 7 |
| 35-U | Section 35 - Non-Source Area | 25,000,000 | — | 750 | 45 | 45 |
| | *Section 35 - Uncontaminated Ditches | — | 14,800 | 2,000 | 8 | 8 |
| | TOTALS | | | | 220 | 415 |

* Investigation of these areas has been postponed by USATHAMA.

the Technical Plan presents site specific information including results of previous geotechnical study, disposal history, contaminants present, numbers of Task 6 borings, anticipated numbers of samples, and tentative borehole locations. The number, depth, and exact locations of Task 6 borings may be altered as a result of field reconnaissance or detection of near surface metals.

### 3.3.1.1 Site 26-1: Deep Well Chemical Sewer

This site consists of all the chemical sewers that were used in conjunction with the deep well disposal. Specifically, this site consists of:

- o Two 8-inch steel pipelines approximately 300 ft long. These pipes were used to transport waste from the northeast corner of Basin F to the deep well facility;
- o A 10-inch vitrified clay pipe, 1,250 ft long that transported fluids from the southeast corner of Basin F to Building 802;
- o A 6-inch high pressure steel pipeline about 250 long used to transfer liquid from the pump house to the wellhead; and
- o A 4-inch steel pipeline 500 ft long that transferred the underflow from the clarifier back to Basin F.

#### Disposal History

Soon after Basin F was completed, it became obvious that the basin could not adequately handle the volume of wastes generated on RMA. As an alternative to Basin F, a deep well disposal facility was designed. The deep well disposal facilities were completed in January 1962 and were operated from March 1962 until February 1966. During this period an estimated 164 million gallons (gal) of fluids were injected. Operation of the well was terminated due to a reported link between the injection of liquid waste and an increase in the frequency of earth tremors in the Denver area.

#### Contaminants

Since the material that was transported in these sewers originated in Basin F, the list of contaminants would also be identical to those listed for Basin F. In general, these would include any of the wastes from the

manufacturing facilities located on RMA. Based upon analytical results reported in August 1978 (Asselin and Hildebrandt, 1978, RIC#81324R09), Basin F fluids may contain the following contaminants:

| | |
|---|---|
| Aldrin | Endrin |
| Arsenic | Fluoride |
| Chloride | Iron |
| p-chlorophenylmethylsulfone (CPMS) | Isodrin |
| p-chlorophenylmethylsulfoxide (CPMSO) | Magnesium |
| Copper | Mercury |
| Cyanide | Nitrogen |
| Dieldrin | Orthophosphate |
| Diisopropylmethylphosphonate (DIMP) | Sulfate |
| Dimethylmethylphosphonate (DMMP) | Total phosphorus |

Hydrogeology

The deep well facility is located on a very gently sloping area in the north central part of Section 26. The area is underlain by approximately 50 ft of alluvium which is generally saturated. The water table is at depths ranging from 20 to 30 ft deep. The direction of regional ground water flow trends to the northwest.

Boring Program

The boring program for this site has been modified to decrease the boring spacing from 500 ft to 200 ft. This was done for the following reasons:

- The sewer lines were used to transport large volumes of waste liquids, and in some instances under pressure; and
- Experience has shown that sewers often leak at the pipe joints and by decreasing the spacing, more can be sampled.

The sewers are scheduled for removal at the same time field work for this investigation is proceeding. To minimize possible volatilization of contaminants, sampling will be performed immediately following removal of the sewer lines. Sampling points will be located on 200-ft centers and one sample will be obtained for each sampling point. Samples will be obtained from the 0- to 1-ft interval beneath the contaminated sewer.

Also, a geologist will be present during excavation operations to observe the condition of the pipeline and bedding materials. If any signs of pipeline deterioration, or obvious signs of leakage are detected, this location will be sampled as described previously. In addition, if obvious signs of contamination are noted in the trench sidewalls, samples will be obtained for analysis.

Based on a sampling spacing of 200 ft, a total length of 2,600 ft, a total of 13 sampling points are proposed. This number of sampling points will generate a total of 13 samples to be analyzed. A summary of the boring and sampling plan for this site is presented below:

| Number of Borings | Depth (ft) | Number of Samples |
|---|---|---|
| 13 | varies from 4 to 6 ft | 13 |

A tentative sampling location plan is presented in Figure 3.3-2.

3.3.1.2 Site 26-3 : Basin C

Basin C (Figure 3.3-3) is an unlined basin in the southeastern corner of Section 26. This site is approximately 73 acres in size and has been used to store overflow from Basin A. When Basin A reached its capacity excess liquids would flow northward via open drainage ditches to Basin B and eventually to Basin C. During repair of the Basin F liner, Basin C was used to store Basin F contents. Basin C has also been used to hold water from the Derby Lakes transported via the Sand Creek Lateral. The areal extent of contamination has been estimated at 3,174,000 $ft^2$ with an estimated total of 1,763,000 cubic yards ($yd^3$) of contaminated subsoil (RMACCPMT, 1984, RIC#84034R01).

Disposal History

As with the other unlined basins of Section 26, Basin C was used to hold the overflow from Basins A and B. Aerial photographs indicate the presence of standing liquid in the northwest corner of the basin as early as 1948. By 1964, aerial photographs indicate that Basin C has been enlarged to its current size and that much of the basin displays signs of soil bleaching. In the same photograph, two drainage ditches can be observed in the southwest corner of Basin C, that appear to drain into

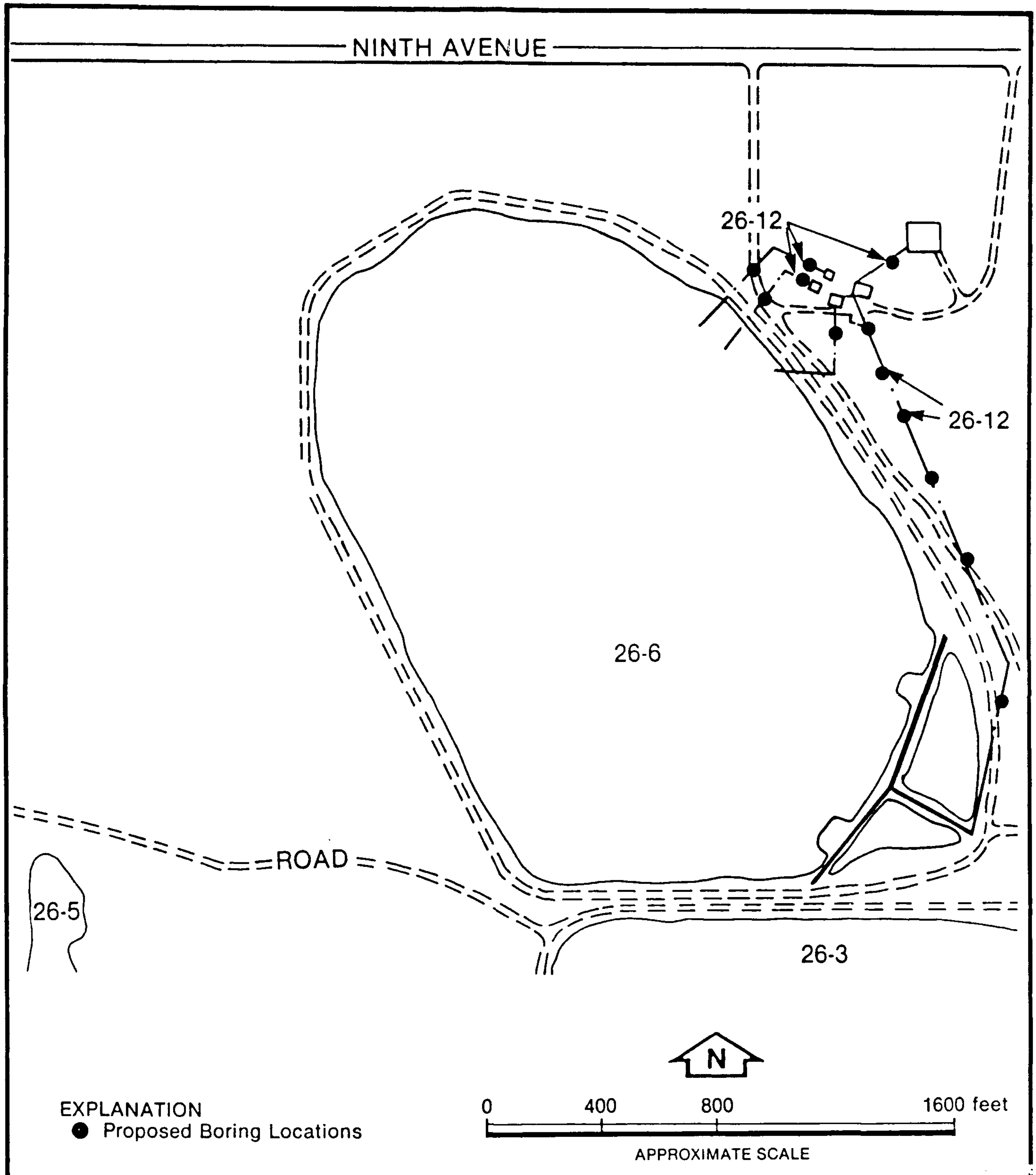



Figure 3.3-2
BORING LOCATION MAP
SITE 26-1
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

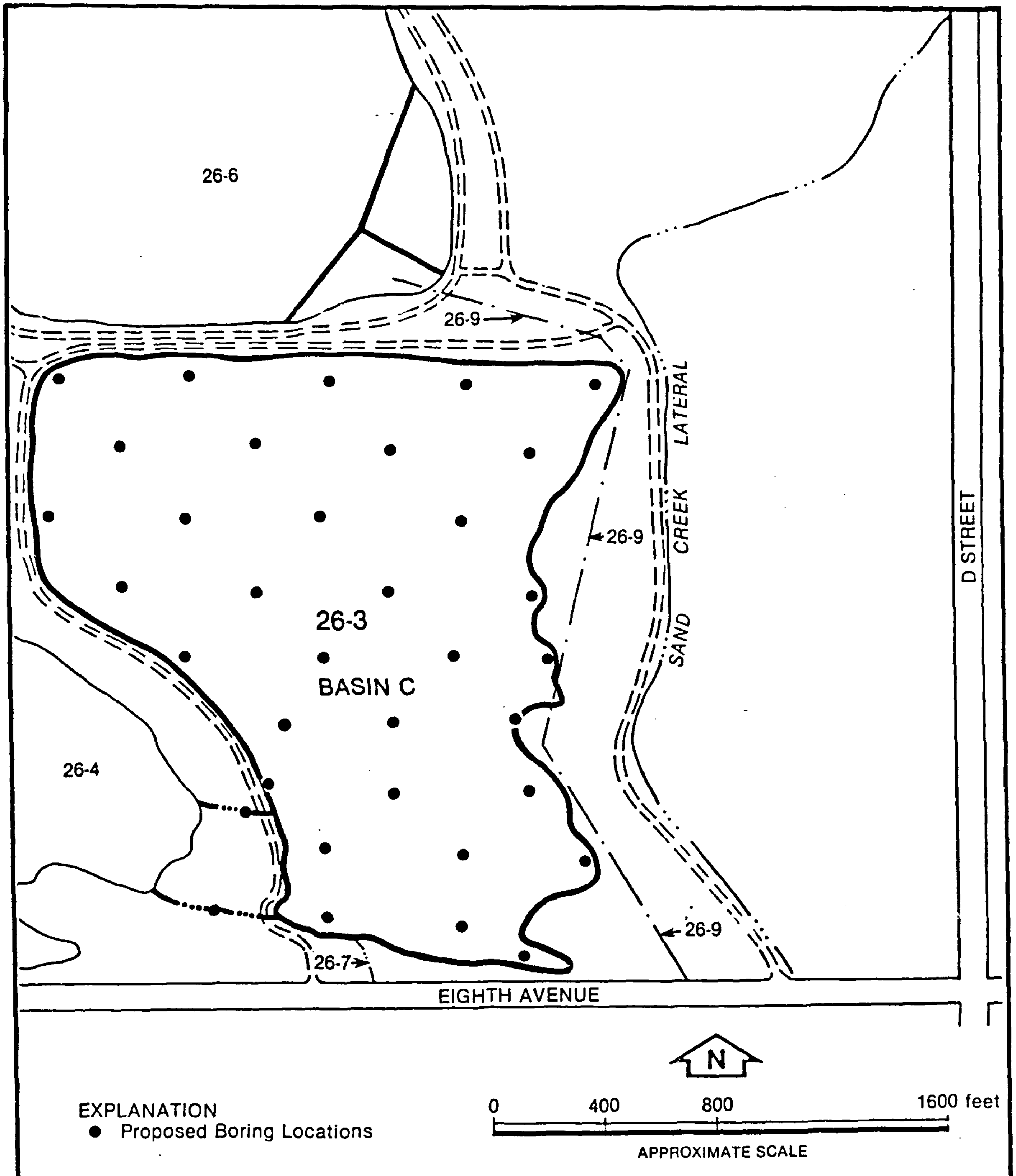



Figure 3.3-3
BORING LOCATION MAP
SITE 26-3
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

**Prepared for:**
**U.S. Army Program Manager's Office**
**For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

Basin D. The existence of these ditches has been verified by field reconnaissance and, therefore, they have been added to the Basin C source. At one point in Basin C history, the basin was used to store a portion of the contents of Basin F while its asphalt liner was being repaired.

By 1970, aerial photographs indicate that Basin C is approximately 40 percent full and the remainder of the basin surface soils have been bleached white. In a 1980 photograph, the basin appears relatively dry and presumably has stayed that way to date with the exception of ponded rainwater or snowmelt.

Contaminants

Basin C received overflow from Basin's A and B; therefore, the liquids impounded in it would have a composition very similar to those stored in Basin A. These compounds would include but not be limited to:

| | |
|---|---|
| Alcohols | Dieldrin |
| Aldrin | DIMP |
| Arsenic | Dithiane |
| Chlordane | Endrin |
| Chlorinated organics | Fluoride |
| Dibromochloropropane (DBCP) | Heptachlor |
| Dichlorodiphenylethane (PPDDE) | Mercury |
| Dichlorodiphenyltrichloroethane (PPDDT) | Organosulfur compounds |
| Oxathiane | Parathion |
| Sodium methyl phosphonate | Sulfate |

As part of the (USAEHA) survey performed in 1973 (Asselin, 1977, RIC#81266R20), soil samples were obtained and analyzed for various contaminants. The results of the survey indicate the presence of aldrin and dieldrin in the soil at concentration of 22 parts-per-billion (ppb) and 220 ppb respectively. Soil samples analyzed by Geraghty and Miller (1982, RIC#81342R06) indicated the presence of DIMP (0.005-0.9 ppm), CPMS (0.1 ppm), CPMSO (0.3 ppm), p-chlorophenylmethyl sulfone ($CPMSO_2$) (400 ppm), copper (2.9-6.2 ppm), and arsenic (3.0-10.0 ppm) in the Basin C soils.

Hydrogeology

Basin C is located over soils consisting mainly of silty or clayey sands that have moderate permeabilities. The alluvium in this area is relatively uniform and 25 to 30 ft thick. The alluvium is saturated only in the southwest portion of the basin. In all other areas the water table is below the alluvium/Denver Formation contact. The water table depth ranges from 20 (eastern half) to 30 (western half) ft below the bottom of the basin. Local ground water flow direction is to the west across Basin C.

Boring Program

Based on an areal extent of 3,174,000 ft$^2$, a boring spacing of 150 ft was chosen resulting in a total of 35 Task 6 borings. Seven of these borings will penetrate to the water table with the remainder of the borings constructed to lesser depths. One boring will be located in each of the overflow channels leading to Basin D. The sampling program is summarized below:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 4 | 30 (WT, W) | 24 |
| 3 | 20 (WT, E) | 15 |
| 14 | 10 | 42 |
| 14 | 5 | 28 |

Approximate boring locations are shown in Figure 3.3-3.

3.3.1.3 Site 26-4 : Basin D

Basin D is immediately west of Basin C. The basin is a natural depression that was dammed to provide additional capacity. Basin D accepted the overflow of the liquids stored in Basin C with the amount of overflow determined by the position of the sluice gate located in the southwest corner of Basin C. A field reconnaissance of the area and a review of historical aerial photographs lead to the discovery of two additional overflow drainage ditches along the west boundary of Basin D that allowed overflow into Basin E (see Figure 3.3-4).

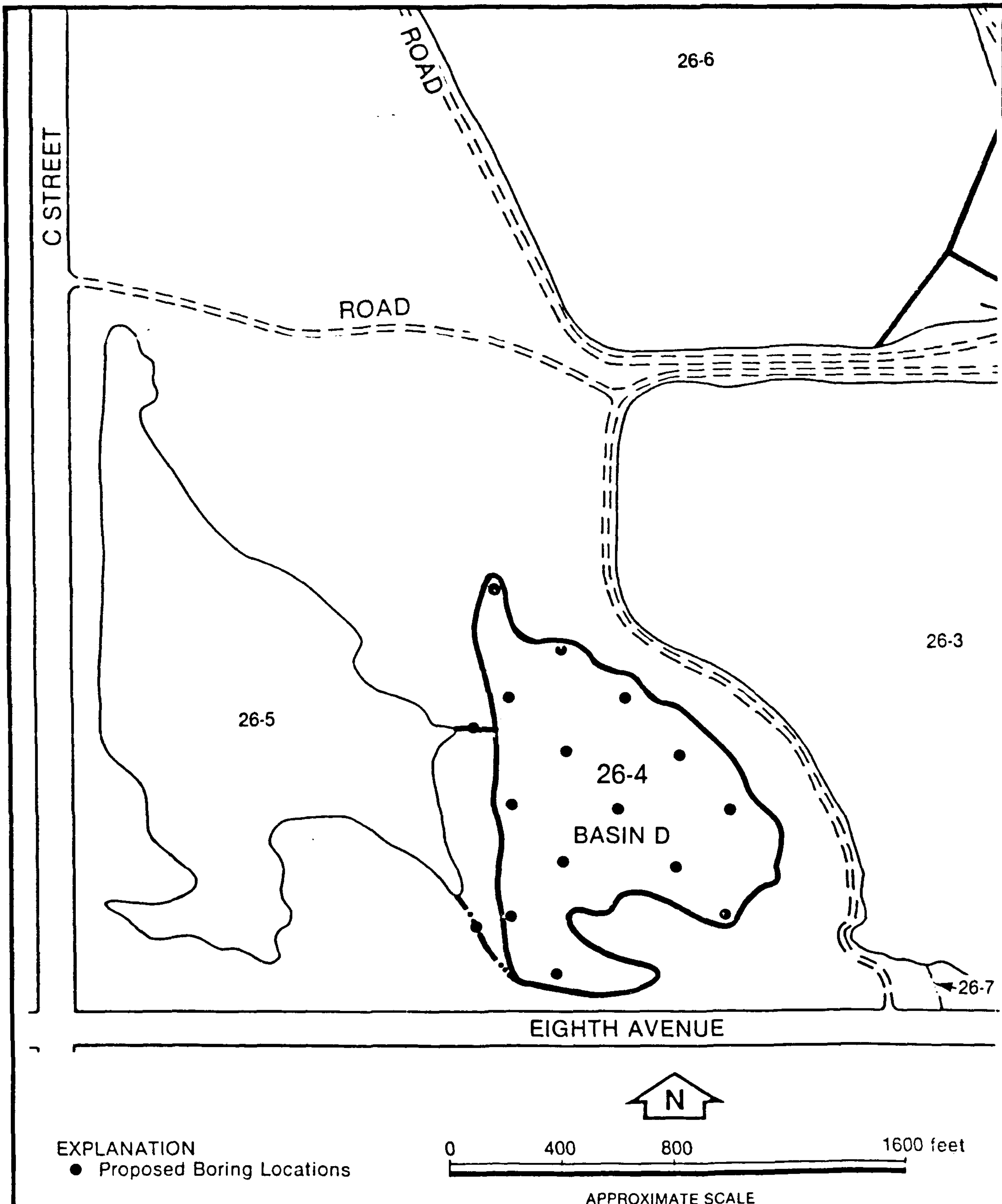



Figure 3.3-4
BORING LOCATION MAP
SITE 26-4
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Disposal History

Basin D was used to hold overflow from the upgradient basins (Basins A, B, and C). As early as 1948, a significant area of standing liquid can be observed in aerial photographs. Approximately 20 percent of the basin is covered with liquid and the remainder of the basin bottom appears to have been recently disturbed (i.e., bleaching of basin soil). The 1948 photograph also showed that the overflow from Basin B flowed directly into Basin D. The direct flow into Basin D from Basin B is still noticeable in aerial photographs taken in 1964 and 1970. By 1970, the amount of fluids had increased to cover about 60 percent of the basin area. The liquid is separated into two pools, located in the northern and southern sections of the basin. By 1980, Basin D liquid levels have been reduced significantly, and occupy less than 10 percent of the basin. Field reconnaissance in June 1985, revealed the basin to be completely dry.

Contaminants

Because Basin D contained overflow from Basins C and B, the compositon of the fluid would have been similar. The types of contaminants that can be expected to be present in Basin D soils are the same as those from Basin C (26-3'). The 1973 USAEHA survey (Asselin, 1977, RIC#81266R20) results indicated the presence of aldrin (310 ppb) and dieldrin (15 ppb). The survey also states that Basin D is a major source of chloride pollution in ground water. The Trost Report (1976, RIC#81281R13) found Basin D to have high sulfate contents. In 1982, Geraghty and Miller (RIC#81342R06) indicated the presence of DIMP (0.1 ppm), $CPMSO_2$ (0.05 ppm), arsenic (0.079-4ppm), and copper (0.01-1.1 ppm) in Basin D soils.

Hydrogeology

Basin D is in a natural depression which overlies approximately 25 to 30 ft of alluvium. The alluvium, except for the northernmost section of the basin, is saturated. The depth to ground water is approximately 30 ft. The direction of ground water flow in the vicinity of Basin D is to the west.

Boring Program

From the estimated areal extent of 877,000 $ft^2$ and Figure 3.3-1, a borehole spacing of 130 ft was selected which translates into a total of 16 Task 6 borings. One boring will be in each of the drainage ditches that flow into Basin E and three borings will be constructed to the water table. The boring and sampling program is broken down as follows:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 3 | 30 (WT) | 18 |
| 6 | 10 | 18 |
| 7 | 5 | 14 |

Figure 3.3-4 shows tentative boring locations. These locations are subject to change based on field conditions at the time of drilling.

3.3.1.4 Site 26-5: Basin E

Basin E is a natural depression that forms an unlined basin just west of Basin D. This site has been used in a similar fashion as Basins B, C, and D to hold overflow from Basin A. The basin has been dammed to increase capacity and currently covers an area of approximately 29 acres. Overflow from Basin D drains into Basin E via two weirs located in the west dike of Basin D. The amount of contaminated sediments in Basin E has been estimated at 711,000 $yd^3$ (RMACCPMT, 1984, RIC#84034R01).

Disposal History

The disposal history of Basin E is similar to that of Basins C and D, in that it was used for the storage of liquids originating in Basin A. Review of historical aerial photographs reveal the following:

- o Standing liquids were present as early as 1948 and covered about 10 percent of the basin;
- o By 1964, the basin had increased significantly in size, with much of the basin area showing signs of recent disturbance (i.e., bleaching of basin soil);
- o The 1970 photograph indicates that Basin E is nearly full (90 percent) and the liquids are contained in two equally sized pools; and
- o By 1980, all the fluids in Basin E have evaporated or infiltrated. Much of the area appears to have revegetated, although some bleached areas are still noticeable.

Contaminants

Due to the similarity of the materials contained in Basin D and E, the types of contaminants that could be found in Basin E are also similar to those in Basin D. The general types of contaminants that may be found in Basin E include those listed under contaminants for Basin C Source 26-3'. The results of the 1973 USAEHA Survey (Asselin, 1977, RIC#81266R20) indicate that Basin E soils contain aldrin (530 ppb) and trace concentrations of dieldrin. Basin E soils have also been shown to contain DIMP (0.05 ppm), CPMSO (0.5 ppm), $CPMSO_2$ (0.5 ppm), arsenic (0.0024-26 ppm), and copper (0.0062-7.1 ppm).

Hydrogeology

Basin E is in a topographic low in the southwest corner of Section 26. This area is underlain by approximately 25 ft of alluvium. The alluvium is saturated under all but the northeastern edge of the basin. Depth to the ground water varies slightly but the average depth is about 20 ft. Ground water flow is to the west across the basin.

Boring Program

Based on an areal extent of 1,280,000 $ft^2$, a boring spacing of 140 ft was chosen resulting in a total of 16 borings to be completed in Task 6. A total of 3 borings will penetrate to the water table with the remaining 13 borings completed to shallower depths. The boring and sampling program is summarized below:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 3 | 20 (WT) | 15 |
| 6 | 10 | 18 |
| 7 | 5 | 14 |

Proposed boring locations are shown in Figure 3.3-5.

3.3.1.5 Site 26-6: Basin F

Basin F is a 93 acre asphalt-lined reservoir with a holding capacity of 245,090,000 gal that was constructed in late 1956 to handle all the industrial waste and wastewater generated on RMA. The basin was constructed in response to claims from farmers that the unlined basins (A, B, C, D, E) at RMA were causing ground water pollution and damaging

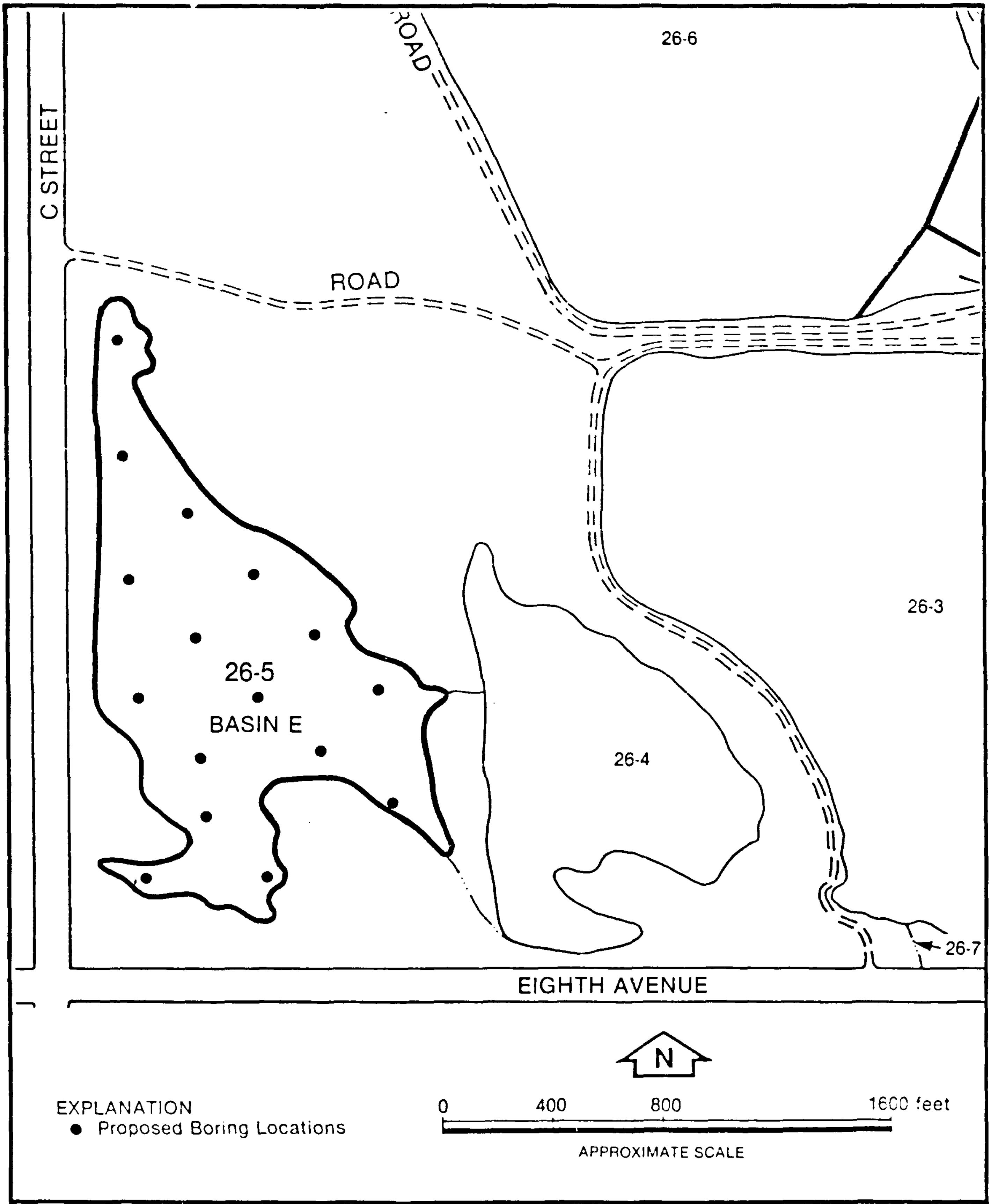



Figure 3.3-5
BORING LOCATION MAP
SITE 26-5
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

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Aberdeen Proving Ground, Maryland

their crops. The liner consisted of a 3/8-inch thick asphaltic membrane sprayed over the prepared basin bottom. A 12-inch layer of soil was placed over the liner to protect it from erosion and degradation due to sunlight.

Disposal History

Transfer of wastes from Basin A to Basin F began in December of 1956, with an estimated 60 million gal of liquid was to be transferred. The transfer operation continued until April 23, 1957, at which time the flow was stopped, because the membrane liner in Basin F had developed a break at the water line. At this time, the basin contained an estimated 105 million gal (approximately half full). Due to this break in the membrane lining, the contents above the break were pumped into the adjoining Basin C, lowering the contents of Basin F by 20 inches. The seal was repaired and rip-rap was placed on the banks to prevent further damage by wave action. By September 1957, the contents of existing contaminated basins were drained into Basin F. Extended chemical sewer lines from the South Plants Area and Sarin (GB) facility carried effluent directly to Basin F.

By spring of 1960, the Basin F level had risen to 195 million gal (80 percent full). In 1962, a deep well disposal unit had been constructed for final disposal of filtered Basin F liquids, at which time the basin was approximately 90 percent full. The use of the deep well was discontinued in 1966. Aerial photographs taken in October 1964 indicate that Basin F is near capacity. By 1966, however, the liquid level in Basin F was extremely low. Extensive areas of the bottom were exposed on the east and south sides and in several places the soil placed to protect the lining had eroded away. An examination revealed extensive breaks in the asphalt lining on the east side. The reported length of the ruptured membrane was approximately 100 ft running parallel to the shore. A more thorough survey was suggested to determine the exact extent of the damage. It was also recommended that Basin F be maintained at a lower level to prevent further leakage into the aquifer. There is no record of repairs being made prior to September 1978, but it is known that the volume of chemical waste being pumped into Basin F increased

significantly in later years and that the liquid level was above the rupture (Buhts and Francingues, 1978, RIC#81266R16).

Up through 1966, it was the practice of Shell Chemical Co. to dump semi-solid waste known as "still bottoms" into Basin F. This material would consist of organic compounds such as product precursors, side-reaction products, high-boiling solvents, etc. (Buhts and Francinques, 1978, RIC#81266R16).

Subsequent aerial photographs indicate the following:

- The entire basin is covered with liquid in April 1970; and
- Only 80 percent of the basin is covered by fluids as of September 1980.

All process discharge to Basin F ceased on December 31, 1981 and the influent chemical sewer line was removed as part of the baseline activities in 1982. Field reconnaissance conducted in June of 1985 indicates the existence of two separate pools of liquid in Basin F covering approximately 40 to 50 percent of the basin bottom.

Contaminants

The disposal history of Basin F and the types of contaminants that can be expected have been well documented. Numerous studies have been conducted to characterize Basin F fluids. The results of a 1978 study (Asselin and Hildebrandt, 1978, RIC#81324R09) indicate that contaminants contained in Basin F fluids include but are not limited to:

| | | |
|---|---|---|
| Alcohols | DDE | Pesticides |
| Chloride | DDT | Phenols |
| Chlorinated Organics | DIMP | Phosphorous |
| CPMS | Fluoride | Sulfate |
| CPMSO | Insecticides | Sulfone |
| DCPD | Metals | |

The results of these studies also indicated that the liquids in Basin F are relatively homogeneous.

A study was performed by the U.S. Army Engineer Waterways Experiment Station (WES) personnel to evaluate the contaminant distribution in Basin F (Meyers and Thompson, 1982, RIC#82350R01). The study included development of sampling protocols for Basin F, leach testing, and chemical analysis of numerous soil cores from the borings constructed below the liner in Basin F. The results of this study indicate the presence of the following contaminants in soils:

| | |
|---|---|
| Acetophenone | Fluoride |
| Aldrin | Isodrin |
| Arsenic | Mercury |
| CPMS | Metals |
| CPMSO | Pentachloroethane |
| DBCP | Tetrachloroethylene |
| Dithiane | Toluene |
| Dieldrin | Trichloroethane |
| DIMP | Xylene |
| DMMP | |
| Endrin | |

Hydrogeology

Basin F was created in a natural depression in Section 26, and its capacity increased by construction of manmade dikes. Limited geotechnical information for soils near the location of cuts indicates that the excavations extended into the upper soils which were thought to be relatively impervious. Portions of the basin bottom, however, may be set into the more pervious sediments associated with the alluvial aquifer. The alluvium is approximately 40 to 45 ft thick beneath the basin. The saturated alluvium thickness varies from 0 to 5 ft. The depth to ground water is about 30 ft in the southern half and 40 ft in the northern half. Ground water flow is generally north to northwest in the vicinity of Basin F.

Boring Program

Based on an areal extent of 4,051,000 ft$^2$ and the quantity of available existing contaminant information provided in the WES Study, a boring spacing of 190 ft was selected (Figure 3.3-1). The total number of

borings for Basin F Task 6 activities is 14, 3 of which will be constructed to the water table. The remainder of the borings will be drilled to lesser depths. In addition to samples obtained from the borings, a sample of the asphalt liner will be obtained at each boring location. The liner samples will be retained for observation of the physical integrity of the liner. The sampling program is summarized as follows:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 2 | 40 (WT,N) | 14 |
| 1 | 30 (WT,S) | 6 |
| 5 | 10 | 15 |
| 6 | 5 | 12 |

Proposed boring locations are shown in Figure 3.3-6. These locations are subject to change based on field conditions.

3.3.1.6 Site 26-7: Basin B-C Drainage

This site, which is an open drainage ditch south of Basin C, is a continuation of Site 35-4 located in Section 35. This ditch was used to transport significant quantities of liquids from Basin B to Basin C. This site is approximately 300 ft in length, and the quantity of contamination has been estimated at 1,000 $yds^3$ (RMACCPMT, 1984, RIC#84034R01).

Disposal History

Review of pertinent RMA documents indicate that this ditch was in use from 1943 to late 1957. Soon after the GB facility became operative, it became evident that Basin A did not have sufficient volume to handle the inflow of industrial waste and wastewaters. The overflow was transported to additional unlined Basins (B, C, D, and E) via open unlined drainage ditches. This site is a portion of the drainage ditch that transported the liquids from Basin B to Basin C. Review of aerial photographs indicate the presence of fluids in Basin B as late as 1975.

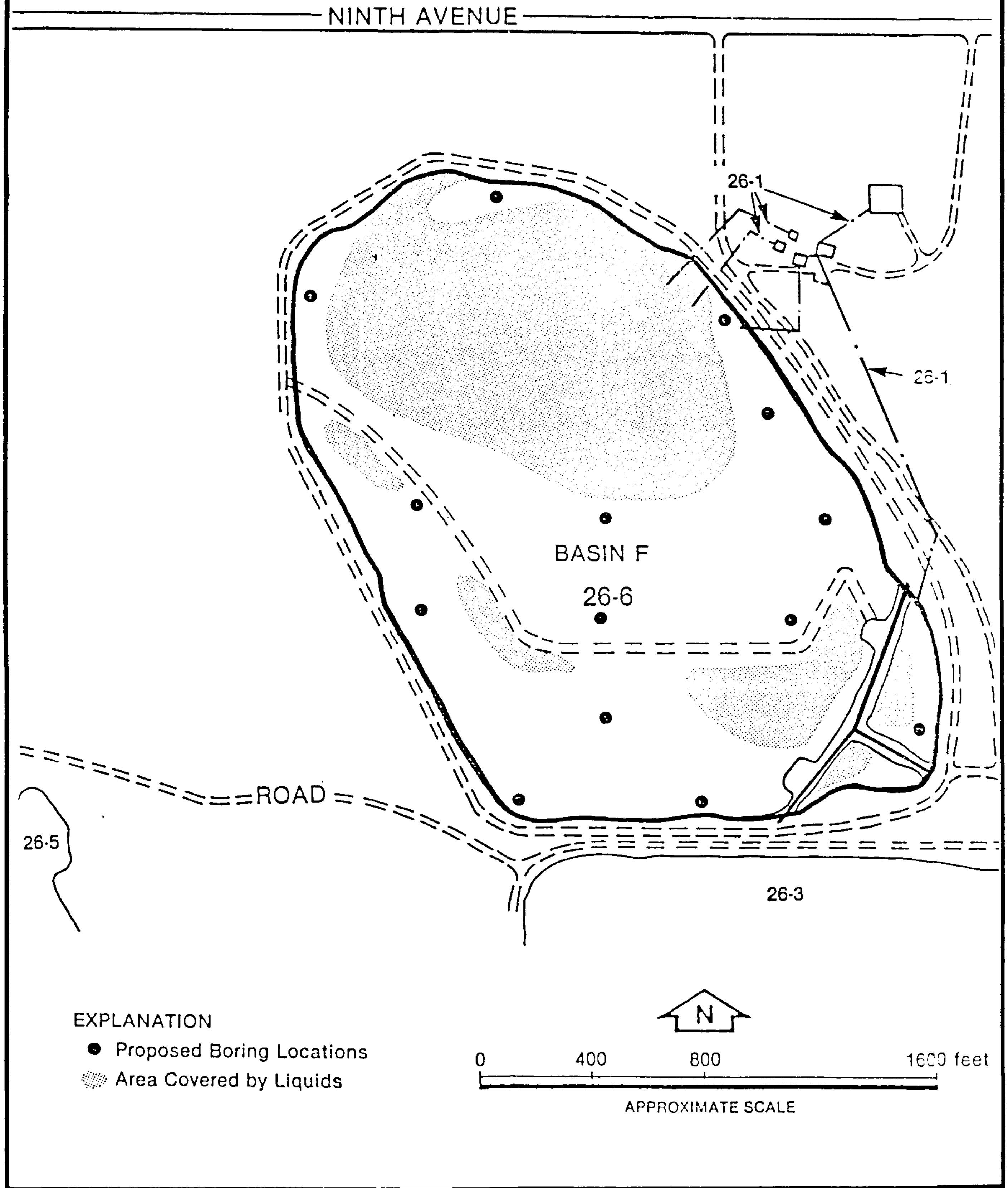


Figure 3.3-6
BORING LOCATION MAP
SITE 26-6
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

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**Aberdeen Proving Ground, Maryland**

Contaminants

As a transport mechanism for liquids initially stored in Basin A and Basin B. The possible list of contaminants for this site is essentially the same as for those basins. The list of possible contaminants for this site includes the following:

| | | |
|---|---|---|
| Alcohols | DCPD | Mercury |
| Aldrin | DDT | Organosulfur Compounds |
| Arsenic | Dieldrin | Oxathiane |
| Chlordane | DIMP | Parathion |
| Chloride | Dithiane | Sodium hydroxide |
| Chlorinated Organics | Endrin | Sodium methyl phosphonate |
| DBCP | Fluoride | Sulfate |
| DDE | Heptachlor | |

Hydrogeology

Site 26-7 is located south of Basin C in an natural drainage depression. Approximately 30 ft of alluvium are beneath this site. The depth to the water table is about 20 to 25 ft. Ground water flow trends to the northwest.

Boring Program

This site has a small linear extent (300 ft) and as such, a boring spacing of 500 ft was selected yielding a single boring. This boring is designed to penetrate to the water table at a depth of about 20 ft. A total of five samples will be obtained. A proposed boring location is shown in Figure 3.3-7.

3.3.1.7 Site 26-9: Chemical Sewer

This site is the northern portion of the chemical sewer that was extended from the South Plants and GB facility to Basin F. The chemical sewer in Section 26 originated in the southeast corner and terminated at the southeast corner of Basin F. The chemical sewer was a continuation of the chemical sewer located in Section 35 (35-2) and was approximately 3,300 ft in length. The sewer was constructed of vitrified clay pipe.

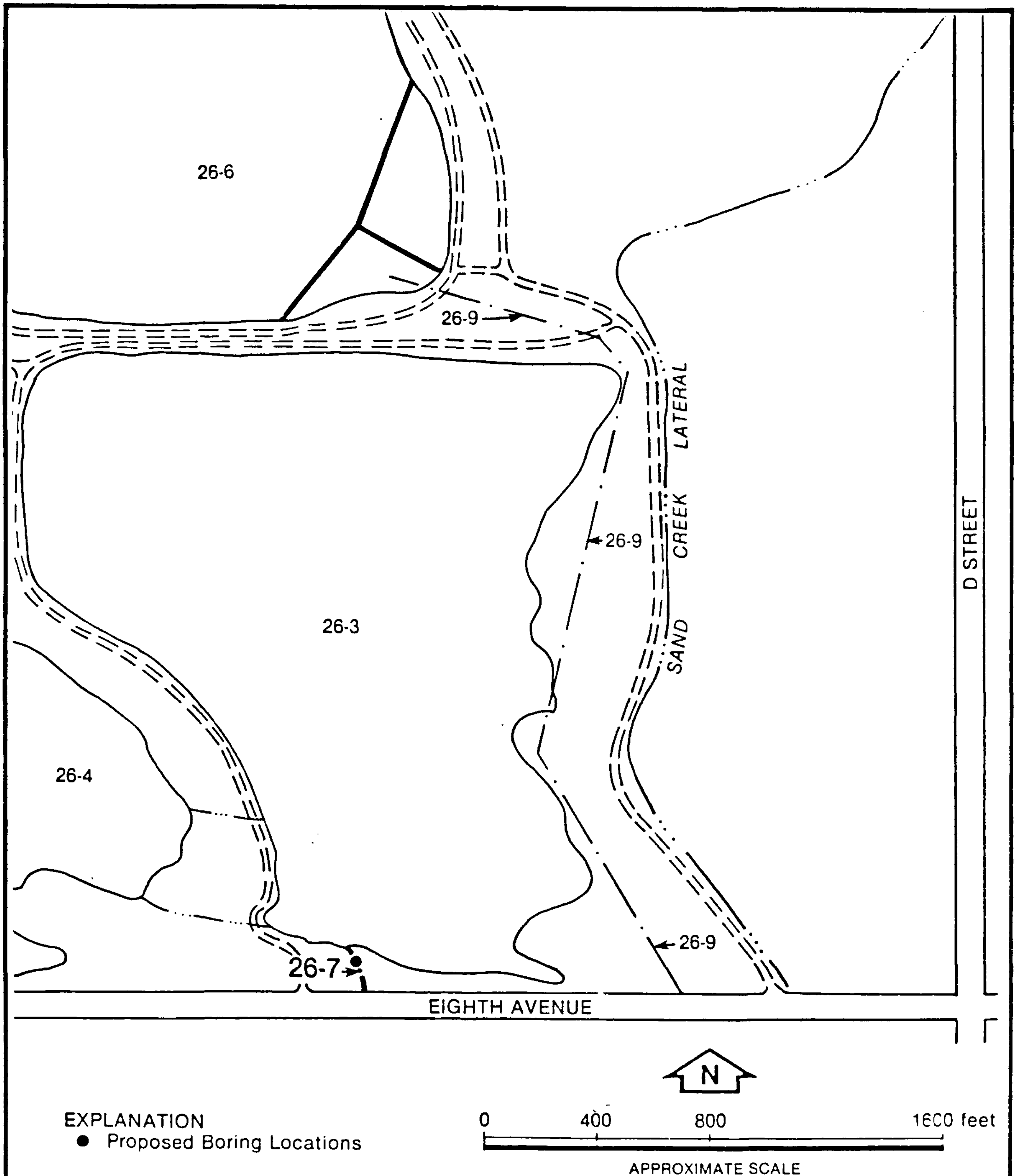


Figure 3.3-7
BORING LOCATION MAP
SITE 26-7
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

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For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Disposal History

The chemical sewer was used to transport all industrial waste and wastewater generated by the South Plants manufacturing area and the GB facility to Basin F for disposal. Several surveys reported that the sewer had numerous leaks and, therefore, as part of the baseline activities, this portion of the sewer was removed in 1982.

Contaminants

The soil beneath the leaking sewer line could have been exposed to a variety of contaminants originating in the South Plants or the GB facility, including heavy metals, pesticides, insecticides, organosulfur compounds, alcohols, fluoride, chloride, phosphates, and sulfates.

Hydrogeology

The chemical sewer alignment is at the base of the topographic high in the southeastern corner of Section 26. Along its alignment, the alluvium varies in thickness from 35 to 40 ft and generally is not saturated. The water table (which is below the alluvium Denver contact) is at a depth of 15 ft at the southern end, and up to 30 ft at the northern end. Ground water generally flows to the west-northwest in the vicinity of the sewer line.

Boring Program

This site has a linear extent of approximately 3,300 ft and a higher probability of contamination. Therefore, a boring spacing of 500 ft was chosen resulting in a total of 7 boreholes. Since the sewer line was removed in 1982 as part of the baseline activities, borings drilled as part of this task will penetrate and sample the bottom of the trench excavated during the removal process. This sampling program will provide sufficient information to evaluate if all contaminated subsoil was removed during the baseline activities. The sampling program is summarized below to the water table:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 7 | varies from 4 to 6 ft | 7 |

A tentative boring location plan is shown in Figure 3.3-8.

3.3.1.8 Section 26 - Non-Source Area

Significant portions of Section 26, not included in specific site boundaries, are considered to be a non-source area. The total non-source area of Section 26 has been estimated by USATHAMA to be 20,000,000 $ft^2$. Review of RMA contaminant maps and (RMACCPMT, 1984, RIC#84034R01) indicated that several sites have been downgraded to non-source areas. These sites include 26-2 (TX Production Area) and 26-10 (TX Irrigation Pond). Table 1.1-1 lists potential contaminant sites that have been reclassified as non-source areas for the purpose of this study.

An adequate number of borings will be drilled and samples obtained to confirm that the non-source areas are indeed background areas that are free of significant contamination. The Section 26 non-source area is in a section with a moderate number of contaminant sites which may have introduced contamination. Therefore, a boring spacing of 750 ft for the non-source area and spacing of 2,000 ft for non-source ditches have been selected, yielding a total of 38 borings, each to a depth of 5 ft. The borings will be arranged as shown in Figure 3.3-9.

The 5-ft cores from non-source areas will be examined and logged to determine if visual subsurface disturbances have occurred at each borehole location. The geologist logging each core will look for evidence of disturbed horizons as well as for the presence of soil discoloration or debris.

For each 5-ft core, a single composite soil sample will be analyzed. The composite soil will be prepared in the laboratory from the intervals of 0 to 1 and 4 to 5 ft. A Phase II boring program is not anticipated in this area.

3.3.1.9 Site 35-2 : Chemical Sewer

This site is the northern extension of the chemical sewer (36-20') being studied as part of Task 1 activities. This portion of the chemical sewer

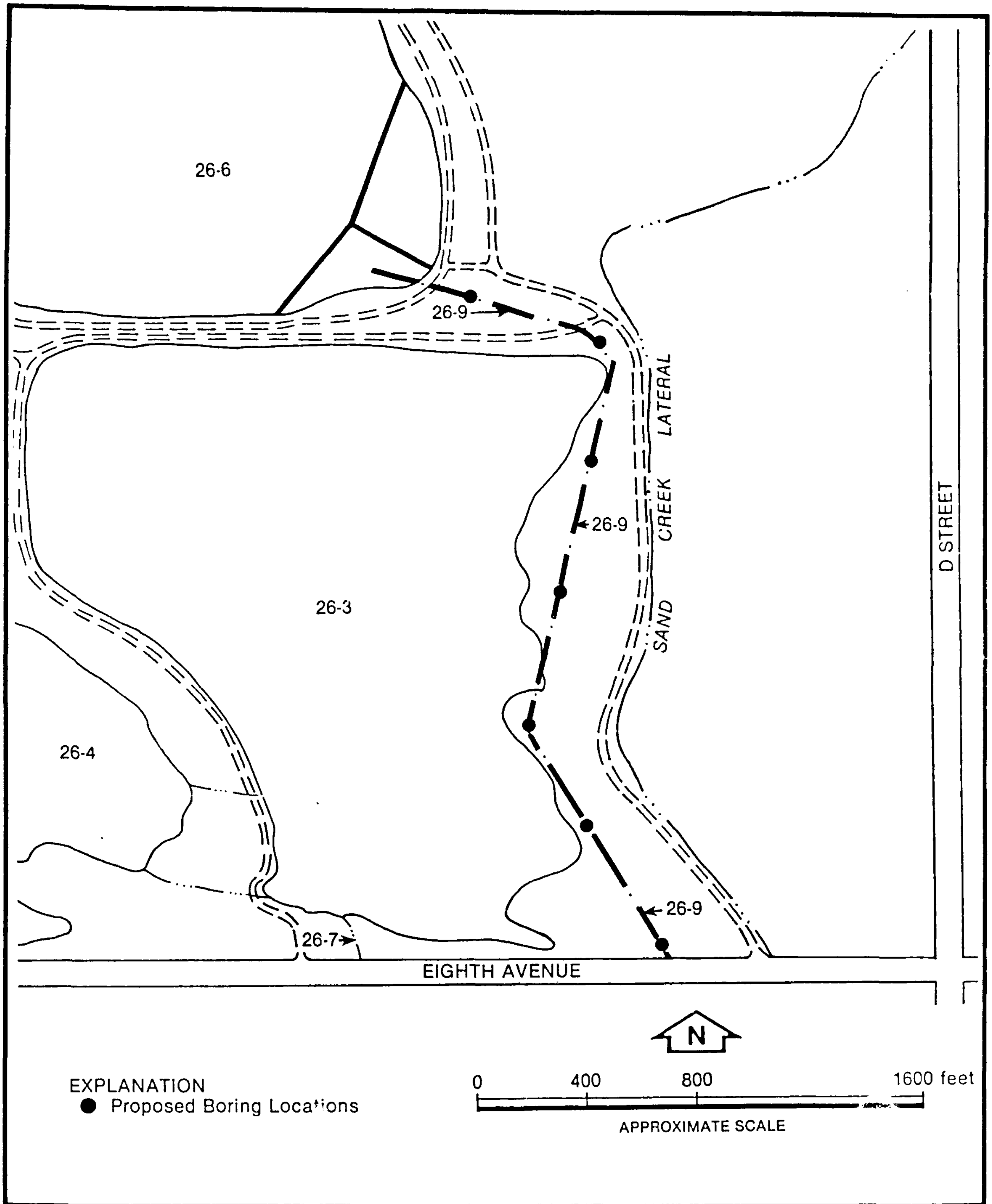


Figure 3.3-8
BORING LOCATION MAP
SITE 26-9
RMA, SECTION 26
SOURCE: HARDING LAWSON ASSOCIATES

**Prepared for:**
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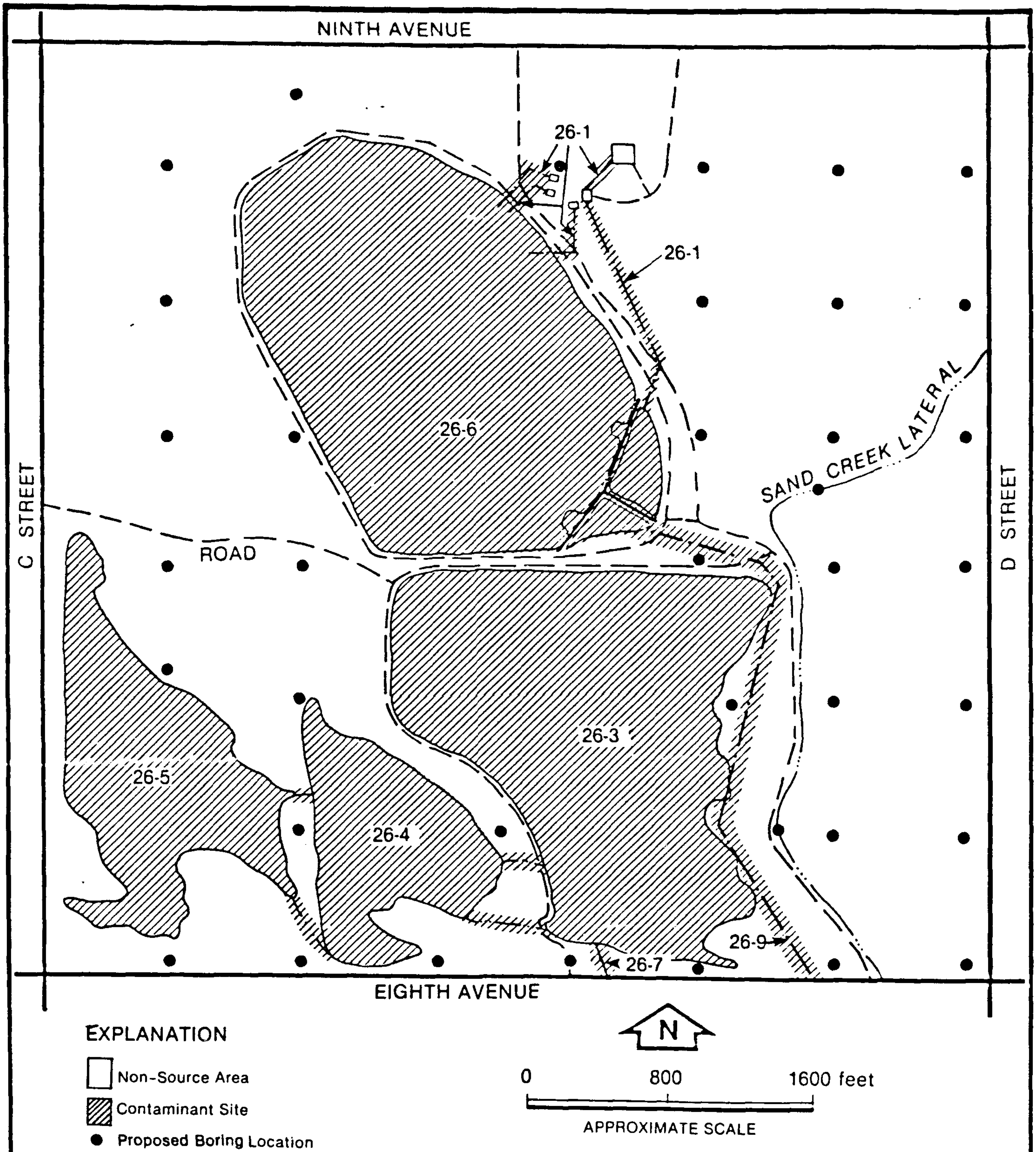


Figure 3.3-9
BORING LOCATION MAP
SECTION 26 NON-SOURCE AREA
RMA
SOURCE: HARDING LAWSON ASSOCIATES

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begins as two separate lines in the southeast corner of Section 35 (See Figure 3.3-10). The two lines converge at the eastern boundary then extend northward terminating at Basin F. This segment of the chemical sewer was removed as part of the baseline activities in 1982.

Disposal History

The chemical sewer was constructed using a vitrified clay pipe and was used to transport chemical wastes from the manufacturing areas to Basin F.

Contaminants

The chemical sewer line carried a variety of chemicals from the Shell and Army facilities including in the South Plants area. These compounds included:

| | | |
|---|---|---|
| Aldrin | Dieldrin | Supona |
| Azodrin | Parathion | Vapona |
| DBCP | Planavin | |

At its northern extent, the sewer line was also used to carry waste and wastewater from the GB plant to Basin F. The following is a list of probable contaminants discharged to the sewer line from the GB Plant:

Hydrofluoric Acid
Isopropyl Alcohol
Sodium Chloride
Sodium Flouride
Sodium Hydroxide
Sodium Methylphosphonate

Several studies have revealed leaks along the chemical sewer line between the South Plants area and Basin F. Although mixing of the chemical wastes with soils and ground water along the sewer alignment is likely, the quantities and extent are unknown.

Hydrogeology

The chemical sewer runs adjacent to the eastern boundary of Section 35 where the thickness of alluvium varies in thickness from 25 to 40 ft. The alluvium is saturated along most of the sewer alignment. Depth to

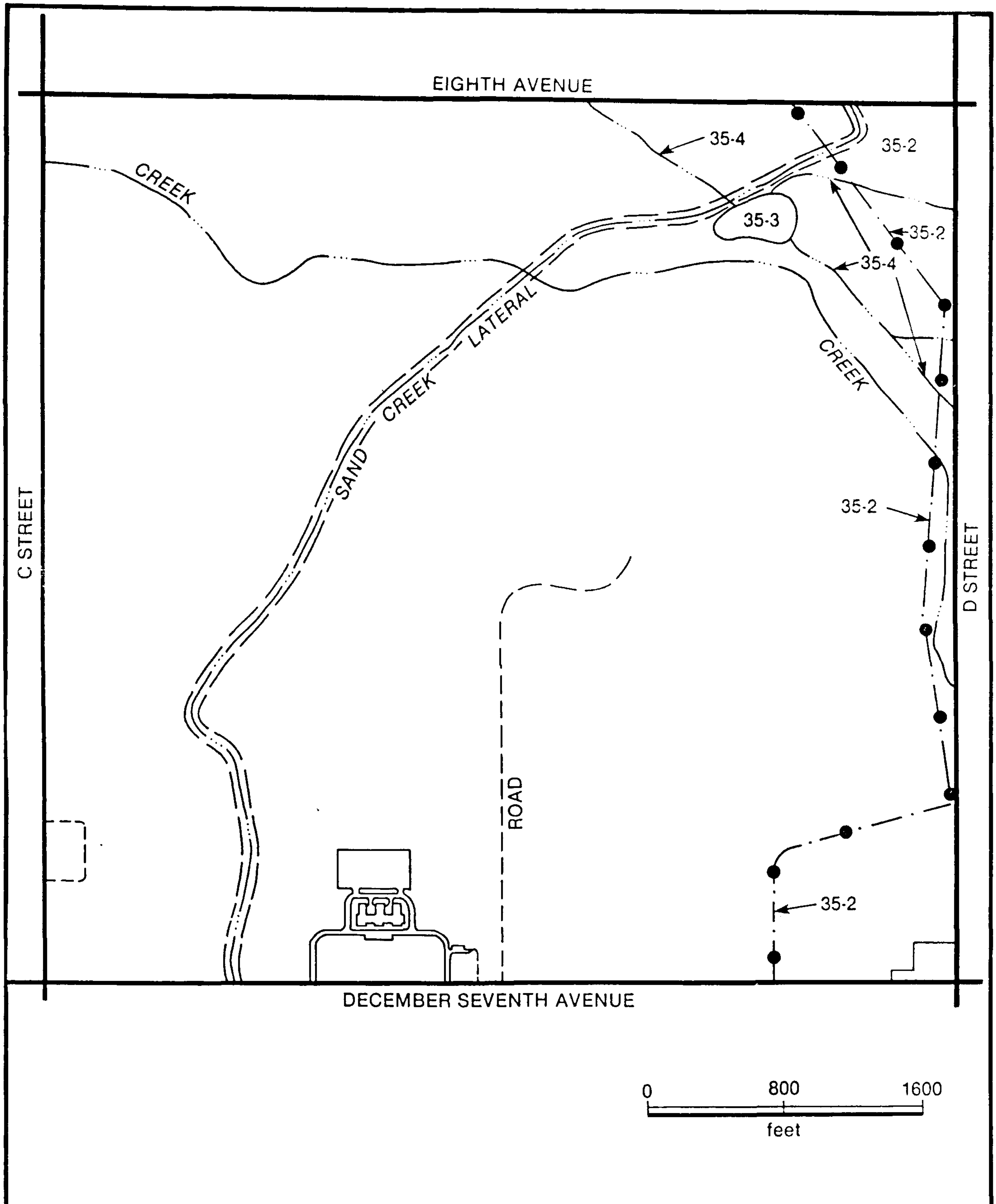


Figure 3.3-10
BORING LOCATION MAP
SITE 35-2
RMA, SECTION 35
SOURCE: HARDING LAWSON ASSOCIATES

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the water table varies from 10 to 15 ft. The water table is at its deepest near the southeast corner of Section 35. Ground water flow across the sewer alignment is in a north-northwest direction.

Boring Program

Site 35-2 has an estimated linear extent of 6,700 ft and has a high probability of containing contaminated fluids. Based on this information, a boring spacing of 500 ft has been selected resulting in a total of 13 boreholes to be constructed. The sewer line and a portion of the underlying soils were removed as part of the baseline activities in 1982. Therefore, all borings constructed in this task will penetrate to the bottom of the trench excavated during the removal process and sample the next 1-ft interval. This procedure will provide sufficient information to determine if all the contaminated subsoils were removed during the baseline activities. A total of 13 samples will be generated in accordance with the sampling program described below:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 13 | varies from 4 to 6 ft | 13 |

Boring locations are shown in Figure 3.3-10.

### 3.3.1.10 Site 35-3: Basin B

Basin B is in the northeast corner of Section 35 (Figure 3.3-11). This unlined basin, which is approximately 2 acres in area, formerly held overflow from Basin A (Section 36). Liquid from Basin A flows through open chemical drainages (Site 35-4) into Basin B. During conditions where Basin B reached capacity, liquids drained toward the north along drainage Site 35-4 into Basin C. It has been estimated that the areal extent of Basin B is 77,000 $ft^2$, and that the volume of contaminated sediment is approximately 43,000 $yd^3$ (RMACCPMT, 1984, RIC#84034R01).

Disposal History

At various times in Basin A history, liquid overflow was carried into and through Basin B on the way to Basins C, D, and E; therefore, liquids which were contained in Basin B would have had a chemical composition

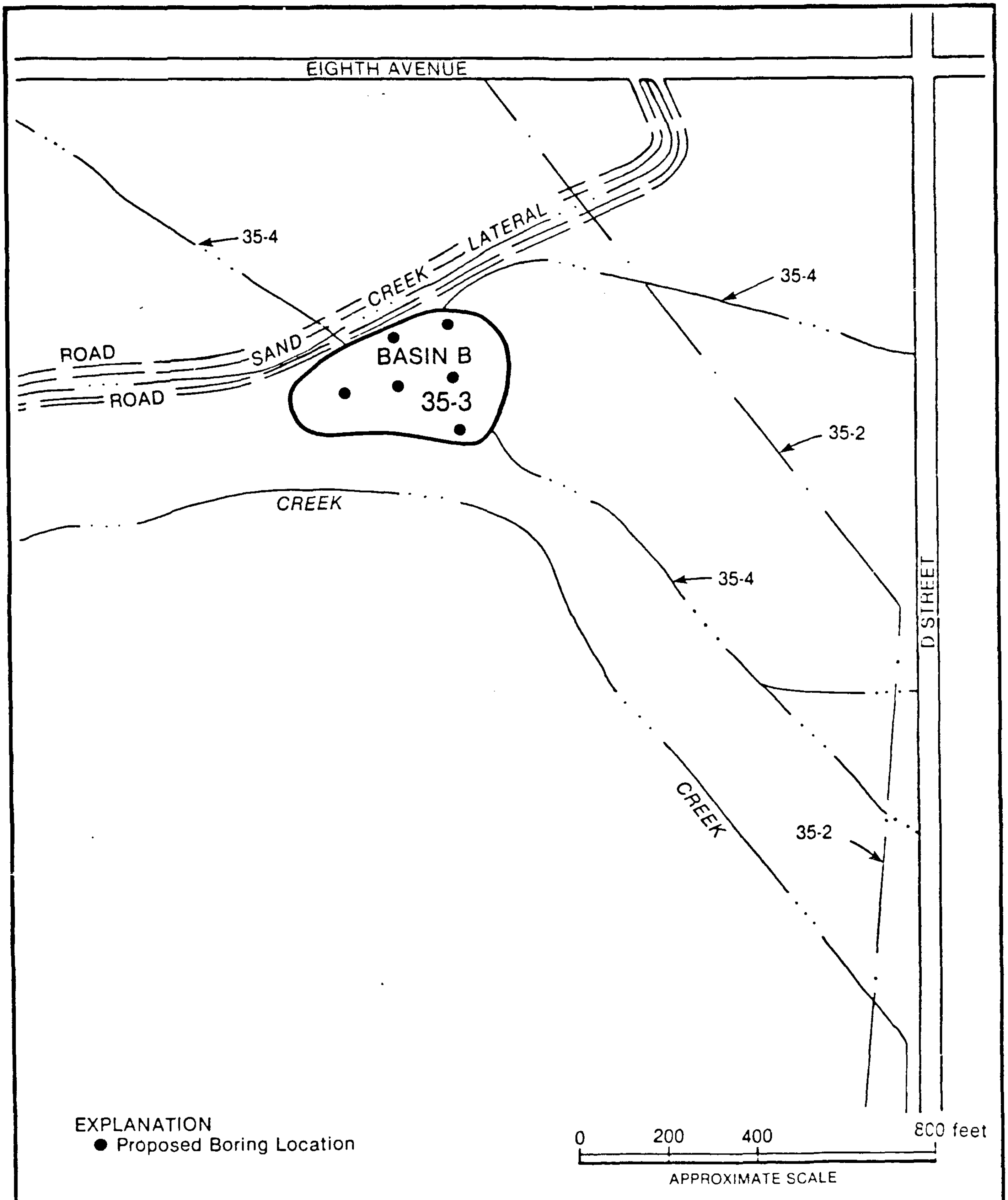


Figure 3.3-11
BORING LOCATION MAP
SITE 35-3
RMA, SECTION 35
SOURCE: HARDING LAWSON ASSOCIATES

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similar to that of Basin A liquids. Until 1957, Basin A was the primary receptor of waste liquids, and overflow entered Basin B. In a 1948 aerial photograph, Basin B is not full, but contains some liquid, and Basin A is close to full capacity. In a 1953 aerial photograph, Basin A is less than half full and Basin B is dry.

In a 1958 photograph, Basin B is full to capacity, but in a 1962 photograph, this basin is less than 30 percent full. Use of Basin A was discontinued prior to 1958, and by 1962, much of the basin had revegetated. In a 1970 photograph, Basin B again appears full, but by the 1975 aerial photograph, it is less than 10 percent full. By 1980, Basin B is completely dry and presumably has remained in this condition since 1980. In summary, Basin B has received liquids from Basin A and has contained these liquids at numerous times from 1948 to the present. Soils in Basin B, therefore, have been exposed to liquids which could have varied significantly in composition but were similar to Basin A liquids.

Contaminants

As Basin B contained liquids derived from Basin A, potential contaminants would include ail those soluble compounds found in Basin A liquids. These compounds would include but not be limited to:

| | | |
|---|---|---|
| Alcohols | DDT | Mercury |
| Aldrin | Dieldrin | Organosulfur compounds |
| Arsenic | DIMP | Oxathiane |
| Chlordane | Dithiane | Parathion |
| Chloride | Endrin | Sodium methyl phosphonate |
| DCPD | Fluoride | Sulfate |
| DDE | Heptachlor | |

Soil samples from Basin B were analyzed for a variety of these contaminants, but were not found in significant concentrations at the levels of detection used. However, reportedly high concentrations of mercury (40 ppm) were observed in Basin B soils (Asselin, 1977,

RIC#81266R20). Soil samples taken by Geraghty and Miller (1982, RIC#81342R06) contained $CPMSO_2$ (0.5 ppm).

Hydrogeology

Basin B is located above the bedrock channel that defines the Basin A neck. The alluvium is approximately 35 ft thick immediately beneath this potential site. The alluvium is saturated and the depth to ground water is approximately 10 to 15 ft. The direction of ground water flow is to the northwest from the Basin A neck through Basin B to Basin C in both the alluvium and the upper Denver Formation.

Boring Program

Based on a areal extent of 77,000 $ft^2$, boring spacing for both Task 6 and Phase II was selected as 60 ft. This results in a total of 6 boreholes for the Task 6 boring program. A total of two borings will be constructed to the water table. The anticipated Phase I (Task 6) program is as follows:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 2 | 10 (WT) | 6 |
| 4 | 5 | 8 |

Tentative borehole locations are shown in Figure 3.3-11.

3.3.1.10 Site 35-4: Basin A-B-C Drainage

Site 35-4 (Figure 3.3-12) is an open chemical drainage ditch which was used to transport overflow from Basin A to Basin B and from Basin B to Basin C. The two portions of Site 35-4 are unlined and carried large quantities of Basin A liquids. The combined length of Site 35-4 is approximately 4,000 ft. The estimated areal extent is 12,600 $ft^2$ and the estimated volume of contaminated soil is 5,000 $yd^3$ (RMACCPMT, 1984, RIC#84034R01).

Disposal History

This open chemical drainage was used to transmit liquid overflow from Basin A to Basin B, C, D, and E over a period in excess of 30 years.

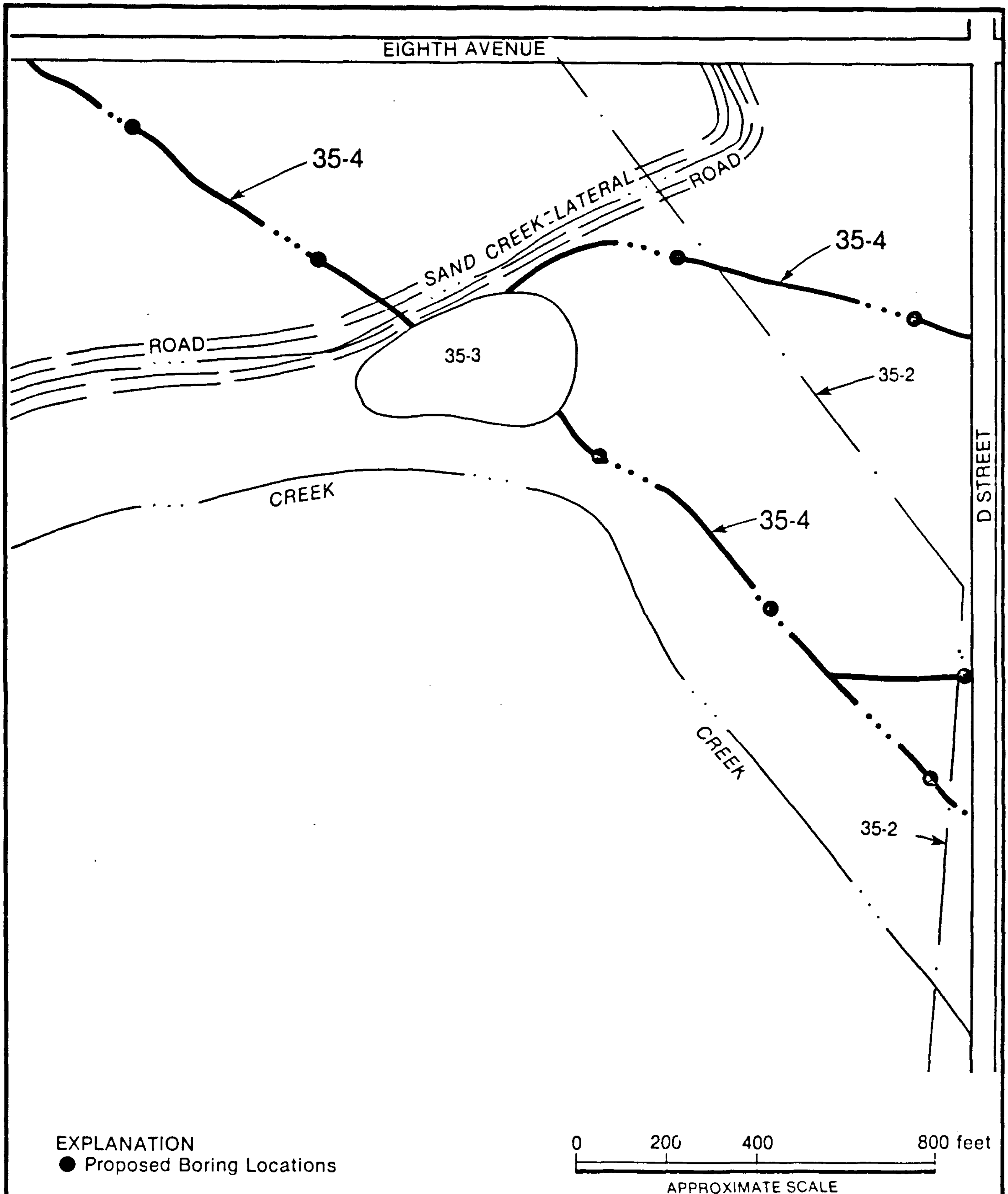


Figure 3.3-12
BORING LOCATION MAP
SITE 35-4
RMA, SECTION 35
SOURCE: HARDING LAWSON ASSOCIATES

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Therefore, the volumes of liquids which flowed through this site are uncertain and the composition of these fluids variable.

Until 1957, Basin A was the primary receptor of all waste liquids. Aerial photographs show that during the period from 1948 until 1958, Basin B contained varying quantities of liquid. These photographs indicate that Basins C, D, and E contained various volumes of liquid. Therefore, these large volumes of liquids were all transmitted through Site 35-4. As evidenced by aerial photographs from 1958 to present, the use of Basin A was discontinued. Liquids, however, were still observable in Basin B until 1975, when Basin B was observed to be almost totally dry.

Contaminants

Liquids transmitted through Site 35-4 were identical in composition to those liquids present in Basin B. Potential contaminants include:

| | | |
|---|---|---|
| Alcohols | DDE | Mercury |
| Aldrin | DDT | Organosulfur compounds |
| Arsenic | Dieldrin | Oxathiane |
| Chlordane | DIMP | Parathion |
| Chloride | Dithiane | Sodium hydroxide |
| Chlorinated organics | Endrin | Sodium methyl phosphonate |
| DBCP | Fluoride | Sulfate |
| DCPD | Heptachlor | |

Hydrogeology

Site 35-4 (open chemical drainage) is situated over the bedrock channel which connects Basin A with Basins C through E. The alluvium varies in thickness from 30 to 40 ft and is saturated. Ground water is present at depths of 10 to 15 ft. Ground water flow in this area trends to the northwest in both the alluvium and upper Denver Formation.

Boring Program

The boring program for Site 35-4 was designed based on an estimated length of 4,000 ft. This site is considered to have a high probability

of containing contaminated soils; therefore, a boring spacing of 500 ft was selected for the investigation in Section 35. The 8 borings to be completed will be constructed to the following depths:

| Number of Borings | Depth (ft) | Samples |
|---|---|---|
| 3 | 10 (WT) | 9 |
| 5 | 5 | 10 |

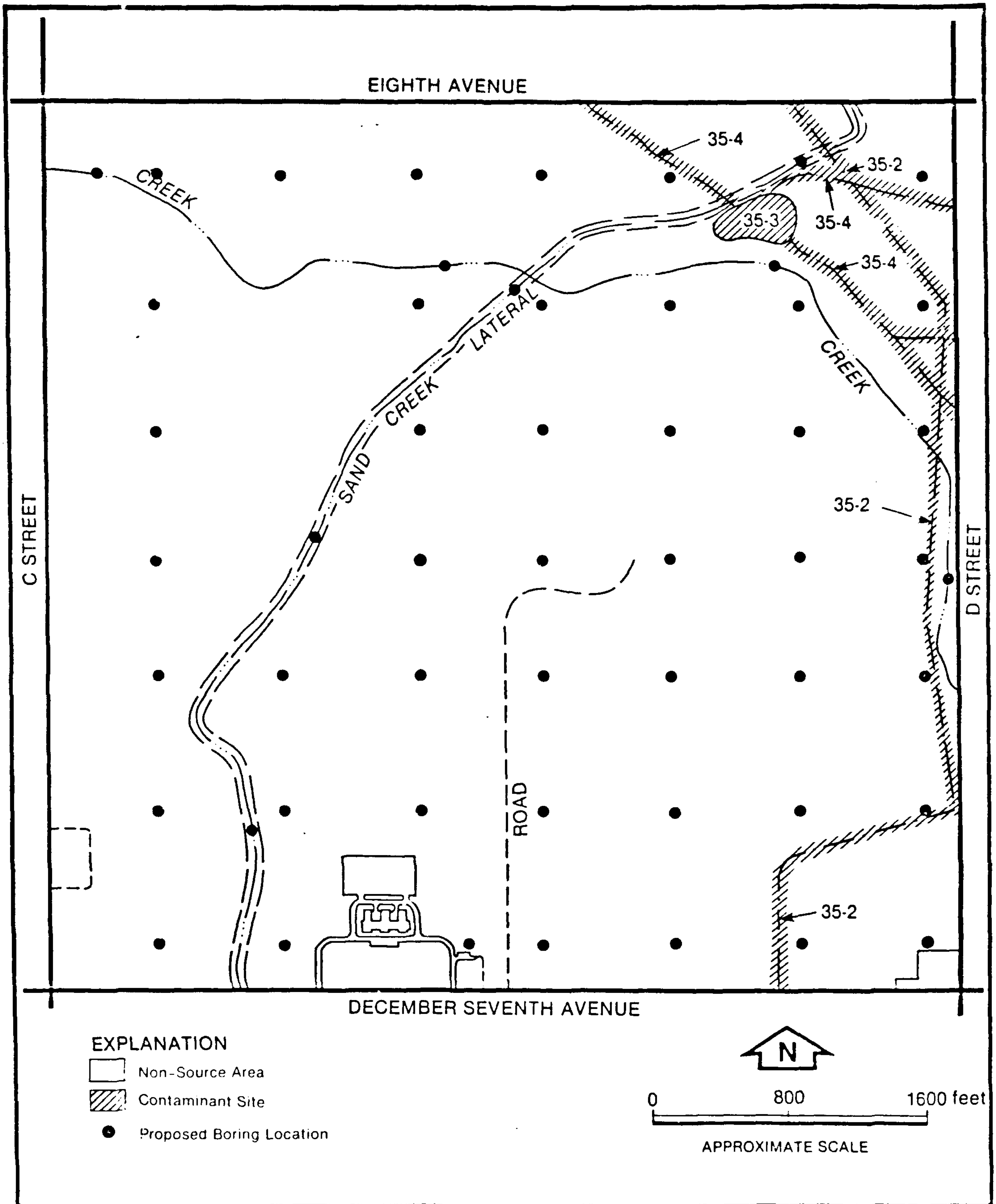
Tentative borehole locations are shown on Figure 3.3-12. These locations may be altered as a result of additional field reconnaissance.

3.3.1.12 Section 35: Non-Source Area

Most of Section 35 is not included within designated site boundaries and is considered to be a non-source area. USATHAMA estimates the total non-source area of Section 35 to be 25,000,000 $ft^2$. Interpretation of aerial photographs and RMA contaminant maps resulted in identification of surficial disturbances and ground scars that are not identified contaminant sites. Table 1.1-1 lists potential contaminant sites within Section 35 that preliminary investigations have classified as non-source areas. These areas include Sites 35-5 (Ground Disturbances), 35-8 (Air Force Storage Area), and 35-9 (Caustic Holding Pond).

In order to confirm that the non-source portions of Section 35, shown in Figure 3.3-13, are free of significant contamination, soil boring and sampling will be performed. Section 35 contains a moderate number of contaminant sites that may have introduced contaminant compounds into non-source areas. Therefore, non-source borings will all be to depths of 5 ft at a boring spacing of 750 ft for non-source areas and at a 2,000-ft spacing for non-source ditches. Boreholes will be arranged in a regular grid pattern as shown in Figure 3.3-13. A total of 53 boreholes are to be constructed in the non-source area of Section 35.

The 5-ft cores from non-source areas will be examined and logged to determine if visual subsurface disturbances have occurred at each borehole location. The geologist logging each core will look for




| | |
|---|---|
| Figure 3.3-13<br>BORING LOCATION MAP<br>SECTION 35 NON-SOURCE AREA<br>RMA<br>SOURCE: HARDING LAWSON ASSOCIATES | Prepared for:<br>U.S. Army Program Manager's Office<br>For Rocky Mountain Arsenal<br>Aberdeen Proving Ground, Maryland |

evidence of disturbed horizons as well as for the presence of soil discoloration or debris.

For each 5-ft core, a single composite soil sample will be analyzed. The composite soil will be prepared in the laboratory from the intervals of 0 to 1 and 4 to 5 ft. A Phase II boring program is not anticipated in this area.

3.3.1.13 Additional Investigations

After the Draft Final version of the Task 6 Technical Plan was completed and the field sampling program initiated, additional sampling was requested at Site 26-6 (Basin F). To facilitate completion of this task, an informal technical plan was submitted to the RMA Program Manager's Office explaining sampling techniques, locations, and analytical parameters. This Letter Technical Plan is included in Appendix A.

## 3.4 SOIL SAMPLING

All test borings will be constructed and sampled using a continuous core augering technique. This technique has been successfully utilized for many geotechnical investigations. With this technique, the entire length of the boring can be examined and contact zones more precisely determined than if standard split-spoon sampling were executed.

The continuous coring technique will obtain 5-ft-length cores within clear plastic "polybutyrate" liners. Although specific sampling intervals have been predetermined, the method of obtaining soil core in polybutyrate tubes will allow the addition of samples to the Chemical Analysis Program from horizons of visually observable contamination in addition to regular sampling intervals. Field measurement of volatile organic compounds using a photoionization detector (PID) will assess the presence of contamination during coring and determine additional sampling intervals where appropriate. Sample cores will not be logged at the boring site. Logging and sampling of soils for chemical analysis will be done at the support facility in the sample handling trailer. This procedure will minimize the risk of sample contamination from windblown

particles or precipitation. A detailed description of the sample handling procedure can be found in Section 3.4.2.

Once the samples for chemical analysis are obtained, the cores will be resealed and stored. Cores will be available if additional core interpretation is deemed necessary, but further chemical analyses may not be possible if sample holding times are exceeded.

### 3.4.1 DRILLING TECHNIQUES

All boreholes will be drilled using an all-terrain vehicle mounted drill rig equipped with hollow-stem augers and capable of continuous-core sampling. If conditions prohibit the rig from constructing shallow borings in areas of soft ground, these borings will be cored by hand. Both techniques are described in later sections. All drilling equipment, including the rig, water tanks, augers, drill rods, samplers, etc., will be steamcleaned prior to arrival at the site. Between boreholes all downhole equipment will be steam-cleaned, using Contracting Officer's Representative (COR)-approved water. All sampling equipment will also be cleaned prior to use. Decontamination and cleaning procedures are described in Section 7.0.

Prior to drilling, a test boring location will have been numbered and staked, and as appropriate, buried metal objects will be located using geophysical methods described in Section 3.2. Borings will be sampled continuously from the ground surface down to a predetermined depth or the water table. The total depth of a boring may be adjusted in the field. If the water table is encountered before the predetermined depth, the test boring will be immediately terminated. Air emissions from the test borings will be monitored during the drilling operations using either an organic vapor analyzer (OVA) or a PID.

The borings will be logged stratigraphically by examination of the continuous cores. The data will be recorded on boring log forms and will include, but not be limited to, boring number and location, date, drilling equipment, driller's name, method of sampling, and soil descriptions. Soils will be classified according to the Unified Soil

Classification System (Sampson and Baber, 1974). Original boring logs will be submitted to PMO-RMA upon completion of the boring.

After the boring is complete and the augers have been removed, the cuttings from the boring will be spread out onto the nearby ground surface. A small board will be placed over the boring until it is abandoned by grouting later the same day. The stake containing the boring location numbers will be firmly placed in the ground next to the boring until the boring is grouted when the stake will be placed in the grout.

3.4.1.1 Continuous Core Augering

It is anticipated that all soil sampling will be performed using an all-terrain vehicle mounted hollow stem auger drill rig with continuous coring capabilities. The continuous coring method advances the 5-ft-long core barrel with the augers, and undisturbed soil samples are collected in clear polybutyrate core tubes. The polybutyrate tubes will be precut in lengths to obtain samples from intervals discussed below and placed in the core barrel for a maximum core length of 5 ft. This sample collection method is anticipated to be utilized for all soil sampling with the possible exception of locations close to ponded water where soil may be extremely soft. Whether all borehole locations will be accessible to the rig and how many locations may not be accessible will be determined primarily by weather conditions at the time of sampling.

For purposes of program estimation, boreholes for Sections 26 and 35 have been designated to be constructed to depths from 1 ft to 40 ft. The following predetermined depth intervals are designated for sampling:

| | |
|---|---|
| 0.0-1.0 ft | 19.0-20.0 ft |
| 4.0-5.0 ft | 29.0-30.0 ft |
| 9.0-10.0 ft | 39.0-40.0 ft |
| 14.0-15.0 ft | |

Although the depth of the deepest boreholes at each site will be governed by the depth to the water table, these sampling intervals will be

adherred to. As stated previously, deepest boreholes at each site will be constructed to the water table.

The need to sample specific depth intervals, the desire for simplicity in core logging, and laboratory requirements for sample collection necessitate the preparation of polybutyrate core tube prior to drilling. The team laboratories require a 1-ft section of core be removed from the core length be sealed, and remain sealed during shipment to the laboratory. Therefore, 1-ft sections of polybutyrate will be pre-cut and placed in the core barrel in positions appropriate to the sampling intervals listed above. Once the core barrel has been removed from the borehole and opened, these pre-cut sections will be removed, sealed with Teflon® film lined plastic caps, and transported to the support facility for shipment. Upon arrival at the laboratory, the sample will be subcored with a cork-borer apparatus to obtain a soil sample which has not been in contact with polybutyrate. This procedure will minimize potential compatibility problems of soils and polybutyrate and reduce the chance of organic compounds being contributed to the soil sample from the core tube.

The remaining polybutyrate core tube, not designated for sample collection, will be placed in the core barrel after being etched longitudinally so that the cut can be completed in the sample handling trailer. Such a longitudinal cut, providing a split core tube, will allow efficient sample logging without the need for extrusion of the core from the tube. These longitudinally cut core sections will be removed from the core barrel at the borehole, taped and capped to hold them shut, and examined by the rig geologist to adjust the depth of borehole construction, if necessary. The taped core sections will be transported to the support facility. In the sample logging trailer, these cores will be opened, logged, additional samples removed if appropriate, retaped, and sent to the core storage area.

The procedures for drilling and continuous coring are as follows:

1. Set up rig at staked and cleared borehole location;
2. Record location, date, time, and other pertinent information on boring log form;
3. Place polybutyrate core tubes cut to specification into core barrel;
4. Commence augering and coring according to the following sequence: 0-1 ft, 1-4 ft, 4-5 ft, 5-9 ft and 9-10 ft, etc. Each predetermined sampling interval is cored in 1-ft sections to insure acceptable sample recovery;
5. At the completion of each coring interval, the core barrel will be removed from the borehole and opened;
6. When appropriate the 12-inch sections for laboratory analysis will be removed, capped with Teflon® film lined plastic caps, sealed with tape, and immediately placed in a cooler;
7. Core sections previously etched lengthwise will be taped and sealed with plastic caps to prevent opening during transport to the support facility;
8. The polybutyrate liner sections will be marked with an arrow pointing to the top end, the boring number, and depth interval. A label giving the same information as well as the project name and number, the date, and the samplers initials will be attached to the core in the sample handling trailer;
9. For each additional 5-ft depth increment to be cored, clean polybutyrate liners will be placed in a clean core barrel;
10. The boring is considered complete when the predetermined depth is reached or the drilling encounters the water table, whichever comes first. For trench disposal areas, the coring will be performed to the maximum depth of observable contamination;
11. All core sections will be transported to the support facility for logging and sample shipment preparation;
12. The boring stake will be left in the ground adjacent to the borehole, and a board placed over the hole until it has been grouted;
13. All boreholes greater than 1 ft in depth will be grouted the same day of construction and the borehole location stake be placed in the grout. One-ft deep borings will be backfilled

with native materials available adjacent to the boring, and the borehole location stake planted firmly in the backfill;

14. Upon completion of each boring, the augers and other downhole equipment will be decontaminated in the field prior to moving to the next borehole location. When all borings in a specific site have been completed the drill rig will be initially cleaned at the site location. Upon completion of the initial cleaning the drill rig will be transported to the decontamination pad where it will be thoroughly steamcleaned before entering another site area;
15. Enough augers and core barrels will be available such that one set may be in use while a second set is being decontaminated;
16. At the end of the working day all equipment, except the drill rig, and personnel will proceed to the decontamination pad where decontamination procedures will be initiated. Decontamination procedures are described in Section 7.0.

In addition to the procedures listed above, borings drilled in Basin F require supplemental setup proceudres. These additional procedures are needed to insure that when drilling through the liner and its overburden, no liquids or waste materials escape into the borehole. WES personnel developed these additional proceudres when conducting their investigation of Basin F. Those procedures have been modified to meet the needs of the Task 6 investigation and are summarized in the next paragraph.

Overburden will be removed from an area approximately 2 ft in diameter using shovels. Extreme care is exercised so as not to disturb the liner. Clean cloth rags will be used to wipe the surface of the liner. A 1-ft-diameter steel caisson will be placed in the hole and bentonite will be poured around the outside of the bottom of the caisson. Outside of the caisson will be backfilled to approximately 0.3 ft with overburden material. The overburden and bentonite will be mixed with a shovel in order to effect a seal between the liner and the bottom of the caisson. Overburden is then backfilled around the caisson to the original surface elevation. At this point, site preparation is complete. Basin F borings

will be abandoned by grouting the borehole and the steel caisson to the surface of the overburden with a cement/bentonite grout.

Shell has indicated that they would like to obtain split samples from the soil cores obtained during field investigation. The following procedures will be utilized to provide Shell with the requested sample:

- o A list of all requested samples approved by the COR will be provided to the field team geologist by PMO-RMA;
- o Upon receiving the approved list, the geologist will coordinate with a representative of Shell as to an acceptable time for sample splitting;
- o The geologist will obtain all the desired smaples from the core storage building and bring them to the loading dock and present them to the Shell respresentative;
- o The Shell epresentative will be required to repackage the cores back to their previous condition; and
- o The ESE geologist will return the cores back to their proper location in the storage building.

3.4.1.2 Hand Cored Sampling

An alternative sampling method may be necessary to construct the shallow boreholes where the ground surface is so soft as to be inaccessible to the drill rig. These areas are most likely located in areas where the water table is very close to the ground surface, and borehole depths will probably be limited to 1 or 2 ft. A description of this method follows.

In areas inaccessible to the drill rig, continuous cores will be obtained by pushing or driving a 1-ft section of polybutryate liner into the ground. A piece of Teflon® film and plywood will be placed over the top of the polybutryate tube and the tube will be pushed or driven into the ground by hand. The tube will be removed from the ground by shovel, the tube exterior wiped clean, the ends capped with Teflon® film lined plastic caps, and sealed with tape.

For soil samples collected in Basin F, the asphalt liner and overlying sand will be removed prior to sampling. A portion of the asphalt liner

will be obtained and saved to document the liner condition. Sampling will commence at the base of the asphalt liner material. Following sampling, the disturbed area will be resealed with grout.

The sample tubes will be marked with the boring number, the depth interval sampled and the upward direction. A label will be taped to the outside of the core. This label will include the same information written on the sample tube, as well as the project name and number, the date and the sampler's initials. Labels will be used in accordance with the procedures established in Section 6.0 (Data Management Plan) of Task 1 Technical Plan. The cores will be logged and stored in a cooler with commercially available Blue Ice prior to and during transport to the support facility sample handling area where they will be logged and prepared for shipment.

### 3.4.2 SAMPLE LOGGING AND HANDLING

After each test boring is completed, the cores will be taken to the support facility sampling logging area to be logged and samples prepared for shipment. The cores will be placed on clean plastic sheets and examined, in order, from the surface sample downward. Descriptions of the soil and other observations will be recorded on boring logs as established in Section 3.4.1.

The cores will be examined for visible indications of contaminants. If these are present, additional soil samples will be obtained from these intervals in addition to samples from predetermined depth intervals. If there are no visible contaminants or if the visible contamination occurs throughout the core, samples from regular depth intervals, collected in 12-inch core tube sections will be sent to the team laboratories.

If additional depth increments are designated for sampling and analysis, then the depth increment to be sampled will be cut from the core using clean stainless steel instruments and placed in amber glass jars sealed with Teflon®-lined lids. The sample jar will be marked with the boring number, and depth interval. Also, a label with the boring number, depth

interval, date, project name, number, and samplers' initials will be affixed to the jar.

All samples designated for analysis of volatile organics will come from regular depth intervals, as sealing in the 12-inch pre-cut core tube will minimize evaporation of volatiles. The laboratory will sub-core these samples and perform the methanol dispersion method for volatiles. No samples from 0 to 1 ft or additional depth increments will be submitted for analysis of volatile organics except from beneath the Basin F liner.

The depth increments sampled will be recorded on the boring logs. The samples will be labelled with the boring number, depth interval, date, project name and number, and sampler's initials. All field data for these samples will be recorded. The samples will be stored at 4°C in ice-filled coolers or in a refrigerator.

### 3.4.3 CHAIN-OF-CUSTODY

Chain-of-custody forms will be completed and will accompany the samples. The data on the forms will include the boring number, the depth interval, date sampled, project name and number, and signatures of those in possession of the samples. A description of chain-of-custody protocol is included in Section 5.0.

### 3.4.4 SAMPLE SHIPMENT

Samples will be shipped daily by air freight to the project laboratories. The 1-ft polybutyrate tubes will be sealed in plastic bags and placed in cardboard tubes. Each cardboard tube will be labeled with the boring number and sample interval. The cardboard tubes will be placed in a plastic bag and shipped in heavy duty coolers filled with ice in sealed plastic bags. The sample jars will be wrapped in bubble wrap, placed in plastic bags, and shipped in heavy-duty coolers filled with ice in sealed plastic bags. Corresponding chain-of-custody forms will be placed in water proof bags and also put into the coolers. Details on sample shipment are found in the Quality Assurance Plan portion of this document.

### 3.4.5 CORE STORAGE

After the samples have been removed from the cores, the cores will be taped shut and the ends sealed with plastic caps which are also taped. The labels should be checked and reattached. The cores will be stored in core boxes in Building 728, located in the South Plants Area.

### 3.4.6 BORING ABANDONMENT

Each soil boring greater than 1 ft in depth will be sealed by grouting on the day in which the boring was completed. Borings 1 ft in depth will be backfilled with native soils. The grout will be composed of 20 parts cement to 1 part bentonite with enough water (COR-approved) for a pumpable mixture. For the deep borings, greater than 20 ft, the grout will be pumped through a tremie pipe placed at the bottom of the boring. The grout will be pumped until undiluted grout flows to the grout surface. For the shallower borings the grout will be poured in from the ground surface. Before the grout cures, the borehole location stake will be set into the grout. This stake will be painted fluorescent orange and labeled with the boring location number. Grout settlement will be inspected after 24 hours and depressions will be filled with additional grout of approved composition. For investigations in Basin F, any sampling area where the asphalt liner has been disturbed will be sealed to maintain liner integrity.

### 3.4.7 SURVEYING

The boring locations and ground-surface elevations of borings will be surveyed by a Colorado registered surveyor as drilling proceeds. For each boring, the boring number, corresponding map coordinates and elevation, and date of measurement will be recorded in the field logbook. The data will be transmitted to PMO-RMA upon completion of the surveying.

## 3.5 SUPPORT FACILITIES

The following onsite facilities which have been constructed for Task 1 will be utilized for Task 6.

1. Decontamination facilities;
2. Onsite offices;

3. Sample logging and handling facilities;
4. Equipment storage building; and
5. Storage building for soil cores.

Onsite offices consist of a trailer divided into several offices. A separate trailer will be used for logging and sampling of cores as well as processing of samples for shipment. Soil cores are to be stored in Building 728. Support facilities utilize a third trailer for showering of personnel and cleaning of small field equipment. The shower trailer will be arranged such that one end of the trailer is for entrance and the other is for exit of personnel from field activities and will be considered "dirty". This end of the trailer will contain changing areas and lockers. The other end of the trailer will contain lockers for street clothes with showers midway between the "dirty" and "clean" portions of the trailer.

Decontamination of large equipment such as bulldozers for drill rig and trucks as well as personnel decontamination will occur at the decontamination pad located adjacent to Basin F in Section 26. The decontamination pad is a concrete structure which drains into a collection sump. Decontamination water will be disposed of as described in the Task 1 Technical Plan.

Final decontamination of large equipment such as bulldozers or drill rigs will be performed on the 20 x 30 ft concrete pad in Section 36. The concrete pad is constructed to drain into a sump from which water will be placed in 2,500 gal polyethylene tank to be temporarily retained onsite. These waters will be chemically analyzed and if acceptable, discharged to the RMA sanitary sewer system. The concrete disposal pad will have a gravel road leading to it to avoid creating muddy conditions during equipment decontamination operations.

The support facilities located across 7th Avenue from the decontamination pad in Section 1 will include a trailer designated as a site office equipped with sanitary facilities, as well as telephone, water, and electrical hookup. Waters from the showers and sanitary facilities will

be discharged to the RMA sanitary sewer system. Details of criteria for disposing of waters to the RMA sanitary sewer system will be determined upon consultation with RMA and PMO-RMA.

A thorough description of support facility activities including decontamination procedures and schematic layout of the support facility area are found in Section 7.0.

In addition to these initial site activities, a nearby water site will be located and secured. This water will be used for all field activities, including grouting and equipment decontamination. The water will be sampled, analyzed, and approved by the COR prior to initiation of geotechnical work. This water will be free of chlorination and be analyzed for all EPA priority pollutants. Criteria for water characterization will be finalized upon consultation with PMO-RMA and RMA personnel.

## 4.0 CHEMICAL ANALYSIS PROGRAM

The objective of the chemical analysis program is to provide reliable, statistically sound and legally defensible analytical data for soil samples and provide information on the types and levels of contamination at selected sampling locations. During this phase each sample will be screened utilizing semi-quantitative GC/MS techniques, inductively coupled argon plasma (ICAP) emission spectioscopy, atomic absorption (AA) and gas chromatography (GC).

The list of contaminants of concern is the same as that used in Task 1 and can be seen in Table 4.1-1. All the methods that will be used are the same ones previously tested during the Task 1 lab certification process.

The sample handling and preparation techniques will be the same as used previously in Task 1. The one ft sections of soil sent to the lab will be subsampled with a stainless steel coring tube through the center of the core cased in polybutyrate. Samples taken for volatile analyses will be quickly placed into VOA bottles containing preweighed solvent. Non-volatile analytical samples will be mixed thoroughly on the dull side of aluminum foil then transferred to amber bottles with Teflon®-lined lids for storage prior to sample workup. Holding times are those used for Task 1 as are the quality control techniques of $\bar{X}$ and R charts.

Table 4.1-1. Contaminants for Phase I of Concern at RMA
(Page 1 of 2)

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Organic Contaminants

- Ethylbenzene
- Benzene
- Aldrin
- Endrin
- Dieldrin
- Isodrin
- Dibromochloropropane (DBCP)
- Malathion
- Parathion
- Methylisobutylketone (MIBK)
- Chlorophenylmethylsulfide (CPMS)
- Chlorophenylmethylsulfoxide (CPMSO)
- Chlorophenylmethylsulfone ($CPMSO_2$)
- Dicyclopentadiene (DCPD)
- Hexachlorocyclopentadiene (HCCPD)
- Chlordane
- Supona
- Bicycloheptadiene (BCHD)
- Dichlorodiphenyltrichloroethane (PPDDT)
- Dichlorodiphenylethane (PPDDE)
- Atrazine
- Dimethyldisulfide (DMDS)
- Vapona

Table 4.1-1. Contaminants for Phase I of Concern at RMA
(Continued, Page 2 of 2)

| |
|---|
| Organic Contaminants (Continued) |
| Chloroform |
| Diisopropylmethylphosphonate (DIMP) |
| Dimethylmethylphosphonate (DMMP) |
| Dithiane |
| 1,4-Oxathiane |
| 1,1-Dichloroethane |
| 1,2-Dichloroethane |
| 1,1,1-Trichloroethane |
| 1,1,2-Trichloroethane |
| Carbon tetrachloride |
| Methylene chloride |
| trans-1,2-dichloroethylene |
| Toluene |
| Xylenes (o-, m-, p-) |
| Chlorobenzene |
| Tetrachloroethylene |
| Trichloroethylene |
| Inorganic Contaminants |
| Zinc (Zn) |
| Copper (Cu) |
| Chromium (Cr) |
| Cadmium (Cd) |
| Lead (Pb) |
| Arsenic (As) |
| Mercury (Hg) |

Source: ESE, 1984.

## 5.0 QUALITY ASSURANCE

The Quality Assurance (QA) program for Task 6 is the same program defined in Chapter 5 and Appendix B of the Technical Plan for Task 1 (DAAK11-84-0016).

Field sampling QA audits will be conducted on sample handling, field documentation and sample shipment. Laboratory sample handling and analytical techniques will be identical to those used in Task 1. The quality of data will be monitored through the use of $\bar{X}$ and R charts.

All Quality Control (QC) charts, raw data and other formatted data will be reviewed and validated by QA prior to release of the data to Level 2 in the data management system. QC charts and negative reports will be forwarded with comments on a weekly schedule to USATHAMA.

## 6.0 DATA MANAGEMENT PLAN

Data for Task 6 will be handled according to the Data Management Plan in Volume I of the Task I Technical Plan Contract Number DAAK11-84-0016. As outlined in the plan, field data (i.e., map files, ground water stabilized field and field drilling files) will be entered into the Compaq Plus personnel computer in the ESE Denver office and transmitted to the Compaq in the ESE Gainesville office via telephone. The field data will be transferred to the Installation Restoration - Data Management System (IR-DMS), put through the Geotest data check routine, validated, and put in Level 2. Sample number assignments, labels, and logsheets will be made in Gainesville and given to the sampling team. Samples shipped to Midwest Research Institute (MRI) and ESE will follow chain-of-custody procedures described in the Technical Plan for Task 1. Data from lab analyses will be entered into the ESE Prime 750 computer, incorporated with certification and field data, and formatted into field according to the IR-DMS User's Guide. After validation these files will be sent to the Univac using the Tetronix or the Compaq Plus computer, run through the data-checking routine and elevated to Level 2. MRI will transfer validated chemical data using software developed by ESE for remote laboratories (Technical Plan, Task I, Volume II, Appendix C). Using the same procedure as for ESE data, MRI data will be put in Level 2 in the IR-DMS.

# 7.0 SAFETY PROGRAM

## 7.1 EXECUTIVE SUMMARY

The safety program for Task 6 has the same objective as that of Task 1; that all operating procedures will ensure the safety of ESE and subcontracting personnel performing activities related to the site investigations at RMA. The program addresses all of the requirements of DI-A-5239B and fully complies with requirements of the Occupational Safety and Health Act (OSHA). The program also complies with U.S. Army Material Development and Readiness Command (DARCOM) Regulation 385-100, Army Regulation (AR) 385-10, and Department of Army Pamphlet (DA PAM) 385-1 for all activities to be conducted. The program also complies with the ESE Analytical Laboratory Safety Plan.

In general, the safety program for Task 1 meets the safety requirements for Task 6. All responsibilities and authorities of personnel remain the same. Safety training and medical examinations are required for all personnel involved in field activities in Sections 35 and 26. Air monitoring, accident prevention, communications, levels of personal protection, decontamination procedures, work zone delineation, contingency plans, and general site procedures will remain virtually the same as those in Task 1 with some variations. These variations are described below.

## 7.2 VARIATIONS FROM TASK 1 SAFETY PROGRAM

### 7.2.1 WORK ZONE DELINEATION

The site layout for Sections 26 and 35 can be seen in Figure 7.2-1. The hotline extends around the entire boundary of Section 26 except for a small area adjacent to the deep well area. This area, the contamination reduction corridor, will contain a decontamination pad for both vehicle and personal decontamination.

A contractor, hired by the Army, will be performing activities to close down the deep well and surrounding facilities. Work zone delineation will be coordinated with the closure contractor when sampling activities take the field team into the deep well area. Frequent communication will

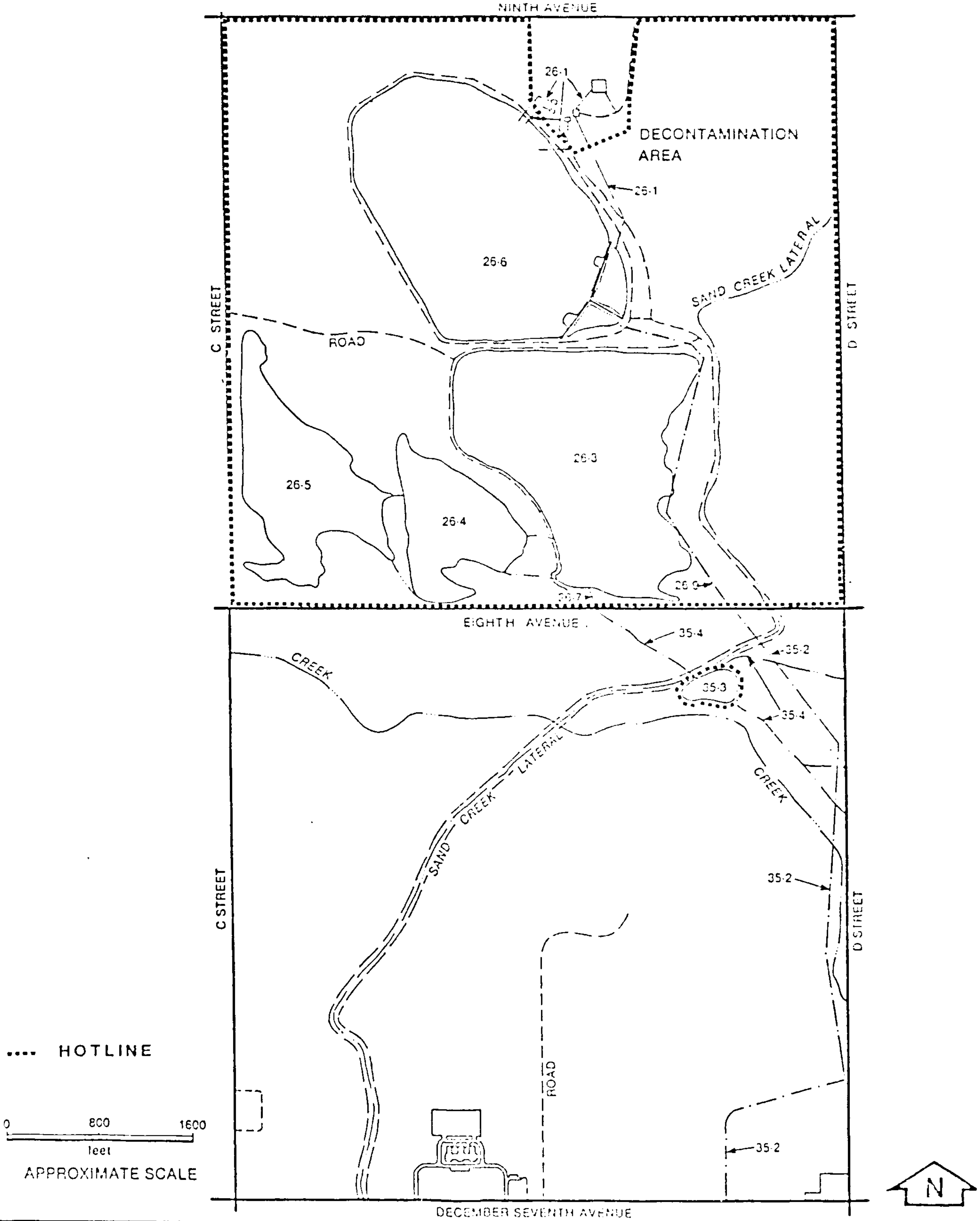


Figure 7.2-1
GENERAL SITE LAYOUT
SOURCE: HARDING LAWSON ASSOCIATES REVISION A, 8/9/85

**Prepared for:**
**U.S. Army Program Manager's Office For Rocky Mountain Arsenal**
**Aberdeen Proving Ground, Maryland**

take place between the field team and closure contractor to avoid hampering either field teams' activities. It may be necessary to modify the hotline on a daily basis when the two field teams are in proximity to one another. The Onsite Safety Officer (OSO) will discuss modifications with the closure contractor's safety personnel prior to making the modifications. All modifications will be clearly marked in the field and team members will be informed of the changes.

The hotline will be marked with rope and orange flagging tape for Site 35-3 because of ill-defined boundaries. Other sites within this section are canals and ditches and as such are clearly distinguishable. The remaining site is the area where the chemical sewer was excavated. The only hazard here will be 5 to 7 ft underground and will pose no immediate danger. Areas outside these hot zones are considered uncontaminated.

There will be no contamination reduction corridor in Section 35. The decontamination pad in Section 26 will be used following activities in Section 35. Because the road between Sections 35 and 26 is a clean area, plastic sheeting will be laid out across the road when vehicles and personnel need to cross to Section 26. This will prevent the road from becoming contaminated. After all vehicles cross the road, the plastic will be disposed of as hazardous.

7.2.2 LEVELS OF PROTECTION

All activities within hot zones will require the same personal protection as prescribed in the Task 1 Safety Program. Activities in the non-source areas of Sections 26 and 35 will be completed in Level D protection. This protection includes normal work clothing with hardhats, steel toe-steel shank rubber boots, and rubber gloves. Respirators will be readily available. If above background concentrations of organic compounds are indicated on the PID, the OSO will immediately stop work and upgrade to modified Level D protection. Modified Level D protection will be worn in all non-source areas of Section 26. Modified Level D includes all items

for Level C, except respirators are ready but not worn. Level C protection will be worn within 30 ft of an open borehole when drilling in site areas on both sections.

Because there is no historical or physical evidence of agent contamination in Sections 26 or 35, no continuous agent monitoring will be done. However, when readings on the PID or other organic vapor detectors are found within the breathing zone, precautionary measures will be directed by the OSO.

Odors from Basin F have been noted in the past as very offensive. Field team members will attempt to shift activities to remain upwind of Basin F. If this is not possible, respirators will be worn if there is an obvious odor emanating from Basin F. Background PID readings will be taken to determine levels of respiratory protection for drilling in and around Basin F.

The field team members will be required to sample a trench following the removal of a sewer line in Section 26 by another contractor. The exact depth and width of this trench is not known at this time. However, sampling activities will be coordinated with the removal contractor. When sampling the sewer trench, it may be necessary for personnel to enter it. However, attempts will be made to sample the trench without entering it. If it is necessary to enter the trench, personnel will enter the enclosed space in Level B protection. A Self-contained Breathing Apparatus will be used as the air supply. OSHA regulations for shoring the trench will be followed. Shoring techniques will be designed after gathering further information from the removal contractor.

### 7.2.3 DECONTAMINATION PROCEDURES

No decontamination will be necessary in the non-source areas of Section 35 unless contaminated soils are indicated through the use of the PID. Decontamination is required for all other areas of Sections 26 and 35. Until a decontamination pad is constructed in Section 26, contaminated vehicles and personnel will cross the road on plastic to Section 36. Vehicles will then drive on the inside shoulder of the road on Section 36 to the decontamination pad on the south side of Section 36.

Once on the pad, Task 1 decontamination procedures will be followed. When the decontamination pad is completed in Section 26, Task 1 decontamination procedures will be followed. Water used for decontamination will be collected in a sump and pumped into barrels for proper disposal.

During drilling activities in contaminated areas of Section 35, decontamination will take place on the pad in Section 26. Plastic will be placed on the clean road to prevent the spread of contamination when contaminated vehicles and personnel cross to Section 26.

Samples will be shuttled to the road during activities in Section 26 and site areas of Section 35. This procedure will allow the vehicle and driver transporting samples to the logging trailer to stay in the clean zone. The vehicle and driver will not have to be decontaminated each time a sample comes from the field.

Coolers in which samples are placed will be kept in plastic bags to prevent contaminating the coolers. These bags will then be disposed of as hazardous waste.

# 8.0 CONTAMINATION ASSESSMENT

The data collected during the Sections 26 and 35 investigation will be integrated with existing site background information to assess as far as possible:

- The type of contamination and an estimate of the extent and depth:
- The degree of hazard presented by the contamination;
- The probably cause of contamination;
- The local geologic and hydrologic conditions; and
- The contaminant fate and transport of migration potential.

Each site will be described in as much detail as can be concluded from the Phase I semiquantitative chemical data and limited geologic and hydrologic data. From the sampling scheme in this phase, identification of the presence or absence of Shell chemicals can be made. Geochemical data will be compiled by site, location, and depth to the extent possible.

In conjunction with the above, a proposed technical approach for the Phase II sampling will be prepared and will use two sampling schemes. Condition A, where significant number of sample points are found to be chemically uncontaminated, will use interpolating procedure, kriging, to position the Phase II points. Condition B, in which all points or all but one or two points are contaminated, will require sampling to be performed outward from the site in order to identify the boundaries separating the contaminated from uncontaminated soils. Position this way is necessary because kriging cannot be used for extrapolation. The approach used for each condition is defined in Chapter 8 of the Technical Plan for Task 1.

Memorandum of Agreement (MOA) general comments on this Technical Plan were discussed in MOA meetings September 17, 1985 and November 6, 1985. A detailed discussion of these comments is contained in the minutes of this meeting. Verbal and written comments from EPA representatives and expert witnesses have been incorporated in the content of the Final

Technical Plan. Specific written comments from the Colorado Department of Health (CDH) and Shell Chemical Company along with written responses are included in Appendix B.

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# APPENDIX A

# BASIN F ADDITIONAL SAMPLING

# LETTER TECHNICAL PLAN

ESE

AN RH COMPANY

ENVIRONMENTAL SCIENCE
AND ENGINEERING, INC.

October 1, 1986
17053,034.10

Mr. Don Campbell
Office of the Program Manager - RMA
Contamination Cleanup
Bldg. E4585 - Double Trailer
Aberdeen Proving Ground, MD 21010-5401

Dear Mr. Campbell:

Per the request of Ali Alavi, this letter provides a brief description of our proposed supplemental investigation of Basin F. The purpose of this study is to provide a refined estimate on the area of subliner contaminated soil. In order to provide this estimate, a program consisting of visual observations coupled with limited sampling is proposed.

The existing data base on the condition of the Basin F liner consists of 16 Waterways Experiment Station borings (1982) and 14 Task 6 borings. Data from these two studies consist of chemical anlaysis of subliner soils and visual assessment of the liner integrity. These data have been combined and presented in Figure 1. Also shown on this figure are the 31 proposed liner observation sites and 17 optional sites. The optional sites will be examined if the assessment requires refinement beyond the proposed 31 sites.

Following visual assessment of the 31 sites, a maximum of 10 sites will be chosen for hand sampling with samples taken at 0-1 and 4-5 feet. The objective is to define the boundary between good and poor liner integrity. Sampling sites will be selected where the liner is suspected of being in poor condition. Large areas with good liner integrity and those with extremely poor integrity will not be sampled for obvious reasons.

Analysis of the resulting samples will be limited to a suite of compounds indicative of liner leakage; these compounds are the semivolatile organics and ICP metals (Cd, Cu, Cr, Pb, Zn).

7332 South Alton Way, Suite H Englewood, Colorado 80112 303/741-0639

Mr. Don Campbell
October 1, 1986
Page Two

Following receipt of the analytical data, a map similar to Figure 1 will be prepared showing relative levels of liner integrity. It is our understanding that the PMO will utilize the data to prepare approximate quantities of contaminated subliner soils for removal under Basin F closure activities.

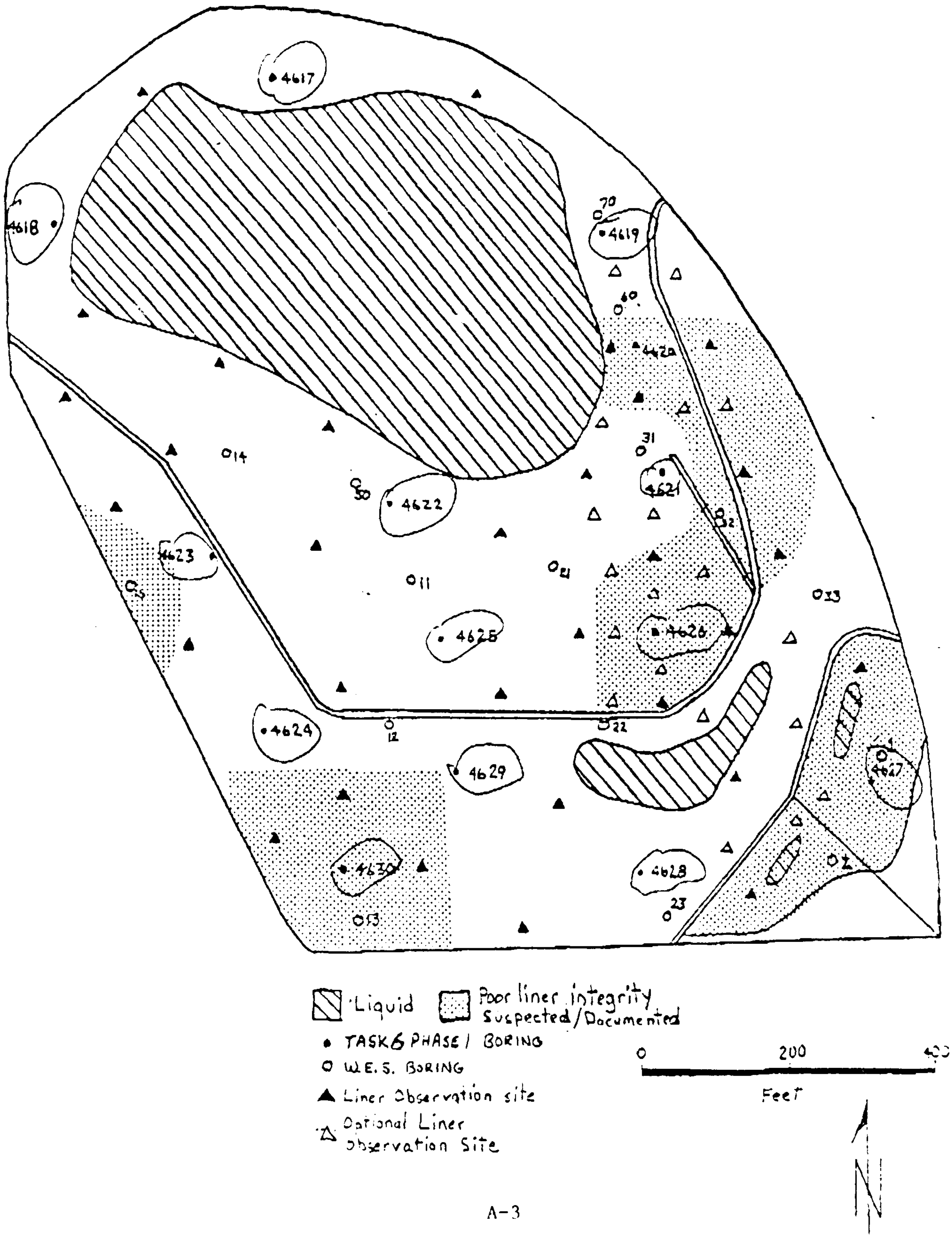
Should you require further information please do not hesitate to call me.

Michael E. Witt, Ph.D.
RMA Task 6 Manager

MW/mas

RMA06-D.1/TPCVRLTR

Figure 1



4617
4618
4619
4620
4621
4622
4623
4624
4625
4626
4627
4628
4629
4630
Liquid
Poor liner integrity Suspected/Documented
TASK 6 PHASE I BORING
W.E.S. BORING
Liner Observation site
Optional Liner Observation Site
0
200
400
Feet
N

APPENDIX B

COMMENTS AND RESPONSES

STATE OF COLORADO

# COLORADO DEPARTMENT OF HEALTH

Richard D. Lamm
Governor

1876

Thomas M. Vernon, M.D.
Executive Director

November 19, 1985

Colonel W.N. Quintrell
Deputy Program Manager
Dept. of the Army
U.S. Army Toxic and Hazardous
  Materials Agency
Building 4435
Aberdeen Proving Ground
Maryland, 21010-5401

RE: Rocky Mountain Arsenal Comment on Tasks 4, 6, 7, 12 Technical Plans

Dear Colonel Quintrell:

We have reviewed the Draft Final Technical Plans for tasks 4, 6, 7 and 12 which describe the Army's consultants implementation plans for conducting the Remedial Investigation/Feasibility Study (RI/FS) at the Rocky Mountain Arsenal. Tasks 4 and 6 were prepared by Environmental Science and Engineering (ESE) and respectively discuss the groundwater and surface water monitoring program proposed for the next 12 months and the soil monitoring program for sections 26 and 35. Tasks 7 and 12 were prepared by Ebasco Services and describe the soils investigation in the vicinity of the South Plants areas and the Derby Lakes area, respectively. Our specific comments are attached and we have the following general comments concerning the Technical plans.

1. All activities relating to the closure of Basin F, the Hydrazine Blending Facility and the Defense Property Disposal Office (DPDO) should be removed from these technical plans. These facilities are hazardous waste management units regulated by the Colorado Hazardous Waste Act (CHWA) and the federal Resource Conservation and Recovery Act (RCRA). The hazardous waste management facilities will be closed and managed under different schedules and using potentially different regulatory criteria than the rest of the Superfund site.

2. Kevin Blose of the program manager's office asked at the last On Post technical meeting that the state concur with the Army proposal to have the Task 4 monitoring program substitute for the 360° Monitoring Program and the CHWA/RCRA monitoring program. As stated above it is not acceptable to have the Task 4 program substitute for the compliance monitoring program presently in effect at Basin F. The CHWA/RCRA facilities will be managed separately from the CERCLA activities at the site.

   We feel it may be appropriate to substitute the 360° program with the Task 4 program but we cannot approve of this change until further



4210 EAST 11TH AVENUE DENVER COLORADO 80220 PHONE (303) 320-8333

information is provided. Specifically the State must receive the results from the past year's 360° monitoring program including well construction details and any interpretive reports made by the Army or its contractors. The off-post 360° program is not addressed in Task 4. In addition we need any contaminant source and plume migration maps and potentiometric surface maps prepared from the water quality and water level data collected in the program. Finally since the analytic parameters proposed for Task 4 are substantially different than those in the 360° program, it is our position that the 360° monitoring program needs to be continued until the differences can be reviewed by the state and incorporated into the new Task 4 program.

Please provide a written response to our comments within 30 days. If you or your staff would like to meet with us to discuss any of the enclosed comments, please contact Mr. Chris Sutton to make the arrangements.

Sincerely,

Robert A. Arnott

for Thomas P. Looby
Remedial Programs Director
Office of Health Protection

TPL:CJS/lre

Attachment

cc: Howard Kenison, Colorado Attorney General's Office
Bob Duprey, USEPA Region VIII
William Lundahl, Shell Chemical Co.
Kevin Blose, Program Manager's Office
Chris Wiant, Tri County
Richard Dehncke, AGO
Larry Ford, SACWSD

COLORADO DEPARTMENT OF HEALTH

GENERAL COMMENTS ON THE

TASK 6 DRAFT FINAL TECHNICAL PLAN

Litigation Technical Support and Services, Rocky Mountain Arsenal, Task 6, Sections 26 and 35 Contamination Survey, Draft Final Technical Plan, September 1985, Environmental Science and Engineering, Inc.

General Comments

The proposed sampling program appears to ignore transport mechanisms and potential flow paths. The program is based on a random grid approach (with a specified density) that does not incorporate what is known about the hydrogeology. This general comment is supported by several specific comments in the next section.

Phasing this type of investigation after some initial data is collected and analyzed would be a very sound approach, not simply between Phase I and II but intc much smaller segments to permit refinement of the field methodology. A planned "stop-analysis-go" process would permit experience gained in the program to be applied.

The review was hampered by not having the following information:

(1) a map of Sections 26 and 35 showing existing soil boring and well locations, and

(2) one map of Sections 26 and 35 showing all proposed soil boring and well locations.

(3) cost information on the proposed study broken down by a) field cost, b) lab cost and, c) data analysis cost.

The Basin F is a CHWA/RCRA facility and must be managed separately from Task 6.

The objectives of the task should be qualified to say that the task will only assess the extent of contamination present in the unsaturated zone. Much more discussion is needed in the plan to indicate how this unsaturated zone data will be combined with the extent of contamination in the saturated zone to support the selection of a final remedial design.

**RESPONSE TO GENERAL COMMENTS OF**
**COLORADO DEPARTMENT OF HEALTH**
**ON THE TASK 6 DRAFT FINAL TECHNICAL PLAN**

The preceeding general comments have been addressed in the following responses to specific comments by the Colorado Department of Health.

COLORADO DEPARTMENT OF HEALTH
SPECIFIC COMMENTS ON THE
TASK 6 DRAFT FINAL TECHNICAL PLAN

1 p. i — Section 3.3.1.9 Change "Source 36-2'" to "Source 35-2'"

2 p. 1-2 — Why is scale approximate? Question applies to all maps.

3 p. 1-3 — Source 35-2 should have a prime.

4 p. 1-3 — How will the "intensive investigation" that has been postponed for Sources 26-8, 35-1, 35-6, and 35-7 be integrated into the present proposed investigation?

5 p. 1-3 — Same question as above for Sources 26-1, 26-9, 35-2' and part of 36-4?

6 p. 1-4 — Why isn't the Sand Creek Lateral considered a source? (Note that on p. 1-15 of the Water Quantity/Quality Survey the statement is made: "The Sand Creek Lateral is a man-made conduit which was used to transport contaminated effluent . . .")

7 p. 1-4 — In the Water Quantity/Quality Survey, p. 1-18, it is indicated that several sections of the Sanitary Sewer are below the water table. Have soil borings been located to avoid these sections?

8 p. 1-4 — What is the justification for investigating sources 26-2, 26-10, 35-5, 35-8, and 35-9 as being uncontaminated? That is, what is the background information mentioned on p. 1-3?

9 p. 1-4 — Uncontaminated areas should be renamed as suspected uncontaminated areas.

10 p. 1-10 — Show outcrop of Denver Formation in Section 35. How was this considered in the soil boring program? Note that this outcrop is not shown in the geologic map in the

Water Quantity/Quality Survey.

11 p. 1-10 Why isn't a soils map shown?

12 p. 1-10 What is a moderate permeability? A low permeability? Can these be quantified? How were the soil permeability data used to help design the sampling program?

13 p. 1-11 Figure legend should be modified to indicate that these are elevations of the top of the Denver Formation. Why aren't data points and values shown? Please provide.

14 p. 1-12 Same comment as above.

15 p. 1-13 Change May 1982 to May (1982).

16 p. 1-14 Please provide data points and values. Also indicate on figure the date when water-level measurements were taken.

17 p. 1-15 Same comment as above.

18 p. 1-19 Provide reference for the statement, "Concentrations of the various contaminants monitored in the fugitive dust were considered not to pose a significant hazard to members of the general population around RMA . . ."

19 p. 1-19 The reference Kolmer and Anderson (1977) is not in the bibliography. Please provide.

20 p. 1-20 Why aren't transport mechanisms, permeability and recharge also being determined.

21 p. 1-20 Why are only semi-quantitative chemical data being obtained?

22 p. 1-20 Bottom of page needs to be continued.

23 p. 1-21 Explain how "a sufficient number of samples" "with a reasonable degree of certainty" will be determined.

24 p. 1-21 What information was received concerning accidental spills?

25 p. 3-1 Opening statement should be modified to reflect that extent of contamination <u>above the water table</u> will be defined.

26 p. 3-1 Please provide the reference (USATHAMA, 1983) in the bibliography.

27 p. 3-1 A somewhat more permanent type of survey marker (rather than "wooden 4 by 4's") would be more appropriate if it is anticipated that future investigations will make use of the coordinate system locations to be established here.

28 p. 3-4 Will the existing fluid in the basins be sampled?

29 p. 3-7 Why wasn't spacing in the "uncontaminated areas" increased in the downwind direction from the known sources, especially the basins?

30 p. 3-7 Why was the boring spacing in the drainage ditches placed at 2,000 ft., which is greater than the spacing in the "uncontaminated areas"?

31 p. 3-7 Why are samples to be composited? How were the intervals 0-1.0 ft. and 4.0-5.0 ft. selected?

32 p. 3-7 "All borings in uncontaminated areas will be constructed to 5 ft. but only a single composite soil sample will be submitted for chemical analysis from each boring."

- Would compositing tend to mask trace levels of contaminants?
- The "grid" approach described by ESE implies no previous work (soil sampling, well drilling and sampling) has been done in Section 26 and 35 because no effort

is described in the boring placement to coordinate with previous work.

33 p. 3-8 "In locations where the presence of volatile organics is not expected only 10 percent of the soil samples will be analyzed for volatile organics."

- Use simple TOC/TOX indicators not a 10 percent arbitrary scan.

34 p. 3-9 Table should be modified to show that actual totals are 197 and 396.

35 p. 3-11 Provide Asselin and Hildebrandt (1978) in the bibliography.

36 p. 3-11 Because sewer line sampling has been postponed (see Table 3.3-1), has the sewer line removal also been postponed? See statement concerning volatilization at bottom of page.

37 p. 3-11 "Basin F fluids may contain the following contaminants:"

- What are degradation/transformation species that are likely?
- No contingency is given if "pure product" or an immiscible phase is found in the core samples or during boring.

38 p. 3-14 How will the lateral extent of contamination be determined without placing some borings outside of the basin, especially in the downwind direction toward the north and northwest?

39 p. 3-14 Proposed boring location on Sand Creek Lateral should be removed.

40 p. 3-15 Basin C should also include Basin F chemicals because

"During repair of the Basin F liner, Basin C was used to store Basin F contents." (p. 3-12)

41 p. 3-22 Concerning Basin F, what sampling will be performed near the water line where the membrane liner developed a leak? What sampling will be performed on the east side where there were extensive breaks in the asphalt lining?

42 p. 3-24 Provide WES (1982) in the bibliography.

43 p. 3-31 On what is the statement "The total uncontaminated area of Section 26 has been estimated by USATHAMA to be 20,000,000 ft.$^2$" based?

44 p. 3-32 Why aren't there more boring locations in Sand Creek, near roads and in topographic lows and drainages?

45 p. 3-36 Provide references for Asselin (1977) and Geraghty and Miller work.

46 p. 3-42 Why aren't more proposed boring locations provided in the southern part of Section 35 near the South Plants?

47 p. 3-43 What is the protocol for visually observing soil contamination in the field?

48 p. 3-43 "The continuous coring technique will obtain 5 ft. length cores within clear plastic 'polybutyrate' liners".

- What is the chemical interaction between "polybutyrate" and the spectrum of organic chemicals expected to be found at the site in the samples?

49 p. 3-45 "Although the depth of the deepest boreholes at each source will be governed by the depth to the water table, these sampling intervals will be adhered to."

- What is the definition of the "water table" which will

be operative in the field?

- If borings are being drilled over time, won't periods of precipitation substantially alter this depth in the unsaturated zone?

50 p. 3-47 "One foot deep borings will be backfilled with native materials available adjacent to the boring."

- A one-foot deep boring.
- A procedure using hand equipment (hand auger, spade) would be more efficient.

51 p. 3-47 Sixteen steps are listed here for conducting borings; however, nothing is mentioned as to what will be done with the material that is produced by the augers as the boring is advanced. This material is potentially highly contaminated and is being brought to the surface and deposited.

52 p. 3-48 "Shell has indicated that they would like to obtain split samples from the soil cores obtained during field investigation."

- The procedure described for Shell to obtain sample splits will is not produce representative split sample results for organic analyses.

53 p. 7-4 "Odors from Basin F have been noted in the past to be very offensive."

- No analysis or characterization of this vapor is given. This must be known in order to determine the level of protection necessary.

54 p. 8-1 In the Phase II sampling, how will the areas be determined for testing for Condition A and Condition B?

**That is, what sample points will be used to determine if more sampling is required?**

55 p. 8-1 **Exactly how will the investigation described here be used to achieve the five objectives listed on this page? The discussion of using the results of this study to guide Phase II work is insufficient.**

56 p. 1-3 What is the rationale to limiting Task 6 to "sources which are most likely to be the result of Shell or Shell/Army activities" and excluding "Army activities from the evaluation? If the reasoning is based solely on the litigation, the distinction is arbitrary and indicates that the conduct of the Task is not consistent with the NCP.

57 p. 3-7 and p. 3-31 Given the situation that the basins have undergone variable use and have experienced extended periods of time where they were very dry, the likelihood of wind blown contaminant migration is very high. For this reason no areas of Section 35 and 26 should be considered as "uncontaminated" until that demonstration is made analytically. Grid-boring spacing for these two sections should never exceed 500 feet.

58 p. 3-11 Sampling beneath contaminated sewer and ditches must be to water table for at least 20% of samples as proposed for the basins.

59 p. 4-3 The analytic parameters must be expanded to include the following:

| | |
|---|---|
| Magnesium | Orthophosphate |
| TOC | Phosphorus |
| TOX | Nitrate |
| Sulfate | Cyanide |
| Chloride | Fluoride |
| Iron | |

DEPARTMENT OF THE ARMY

PROGRAM MANAGER, ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

ABERDEEN PROVING GROUND, MARYLAND 21010-5401

April 9, 1986

REPLY TO ATTENTION OF

Office of the Program Manager

Mr. Thomas Looby
Colorado Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

Dear Mr. Looby:

Attached (Enclosure 1) are our responses to specific comments made by the Colorado Department of Health on the Task 6 Technical Plan (Basins Area-Section 26 and 35) under cover letter dated November 19, 1985, your signature block (signed by Robert A. Arnott). General responses and specific responses on Tasks 4, 7, and 12 have already been forwarded. A copy of your original review comments for Task 6 are included (Enclosure 2). Several general comments precede specific Task 6 Comments/Questions. These comments have been discussed elsewhere or are included in our specific responses. In addition, the response to the Task 14 comments, which will be forwarded to you shortly, further discuss in detail many of these same issues, such as transport mechanisms and potential flow paths.

If you are interested in the cost information on this study, we will be happy to discuss this aspect of the Remedial Investigation Program with you, perhaps at an upcoming MOA meeting.

If you have any questions about the response enclosed or desire further clarification on any point, please contact Mr. Kevin Blose at (301) 671-3261.

Sincerely,

Mr. Donald L. Campbell
Litigation Team Member

Enclosure

Copies furnished with enclosure:

Mr. Chris Sutton, Colorado Department of Health, 4210 E. 11th St., Denver, CO 80220
Major Robert Boonstoppel, Department of the Army, Office of the Judge Advocate General, 1717 "H" Street, NW Matomic Building, Washington, D.C. 20310-2210
Mr. Thomas Bick, Environmental Defense Station, Land and Natural Resource Division, U.S. Department of Justice, P.O. Box 23896, Washington, D.C. 20026
Mr. Connally Mears, U.S. Environmental Protection Agency, Region VIII 1860 Lincoln Street, Denver, Colorado 80295-0699

RESPONSES TO
COLORADO DEPARTMENT OF HEALTH
SPECIFIC COMMENTS ON THE
TASK 6 DRAFT FINAL TECHNICAL PLAN

1.p.i Editorial change noted.

2.p.1-2 The maps presented throughout the text are for the purpose of orienting the reader to the areas under discussion. Recommended borehole locations serve as estimates and may be shifted by the field geologist as a better location or field conditions dictate.

3.p.1-3 Editorial change noted.

4.p.1-3 Sites within the Section 26 and 35 area not addressed under the task will be investigated under Task 14 scheduled for study at a later time. Environmental Science and Engineering, Inc. will conduct the assessment of all sites in Sections 26 and 35, and will be responsible for integrating tasks.

5.p.1-3 See response Number 4.

6.p.1-4 The Sand Creek Lateral will be included as part of the recommended follow on action for 35-UNC and 26-UNC.

7.p.1-4 The Phase I investigation of the sanitary sewer system has been deleted from the Task 6 scope-of-work. This source will be investigated under Task 10, Sewers Investigation, and the specific details concerning the Phase I investigation are presented in the Task 10 Technical Plan. Task 10 includes all sewers throughout RMA.

8.p.1-4 According to historical records at RMA, Sources 26-2 and 26-10 were areas used to grow wheat and hold irrigation water. No chemical contamination is suspected from these activities. Source 35-5 was determined from historical photographs to be a borrow area with no other documented use. Source 35-8 is a parking lot on which non-chemical items were stored while Source 35-9 is a basin area built to hold caustic but was never used.

9.p.1-4 This comment is simply a play on words. The report states that these UNC areas are uncontaminated and to the best of the knowledge from historical review and interviews this is an accurate statement. By adding the word suspected, we would be stating something that is not born out of the recorded facts.

10.p.1-10 Although the outcrop of the Denver Formation in Section 35 is an interesting geologic feature, it has no bearing on the Task 6, Phase I soils investigation. This area is located outside the boundaries of any sources and as such has no bearing on soils contamination in Section 35.

11.p.1-10 The soils map was deemed unnecessary and in our opinion did not add to the technical competency of this plan.

12.p.1-10 Moderate permeability and low permeability are qualitative descriptions of soil properties. These descriptions were provided to give the reader a relative feel of the soil permeability of the various soil types present. The soil permeability data were not used in the design of the sampling program. The Phase I soil investigations have been designed to provide a general description of the soil contamination at a given source. The subsequent Phase II investigations will be designed based on the results of Phase I, at which time relative permeabilities may influence sampling design.

13.p.1-11 Editorial change noted.

14.p.1-12 Editorial change noted.

15.p.1-13 Editorial change noted.

16.p.1-14 The ground water contour map provided was obtained from the May (1982) report of the regional ground water study of Rocky Mountain Arsenal. Data points and values were not available. The water level contour map was prepared using water levels obtained in the third quarter of 1981. No attempt was made to re-evaluate published information of accepted nature.

17.p.1-15 See response to Comment 16.

18.p.1-19 The references that provided a description of the fugitive dust monitored were:

RIC#83192R02. Guzewich, D.C. and D.P. Deeter. August, 1982. Evaluation of Organic Vapor Emissions Basin F, Rocky Mountain Arsenal, Commerce City, Colorado. Part 2 Field Study Results and Health Risk Assessment.

RIC#81293R04. Bond, C.A. and J.A. Thomasino. 1981. Ambient Air Quality Assessment 43-21-0170-81 Rocky Mountain Arsenal, Denver, Colorado.

19.p.1-19 Editorial change noted.

20.p.1-20 Permeabilities, transport mechanisms, and recharge will all be dealt with in a subsequent interpretive ground water task. The purpose of Task 6 is solely an evaluation of soil quality in the unsaturated zone at specific sources and two uncontaminated areas.

21.p.1-20 The term "semi-quantitative" does not infer an inferior quality of data. This term is used to describe data that are accurate to one significant figure. By using the GC/MS techniques, the Army was able to produce a volume of accurate data for a large number of samples to be able to screen the source areas and uncontaminated areas for a long list of analytes and non-target compounds. This technique allowed the best use of resources to quickly screen sample areas and analytes measured to devote the remaining resources to a more detailed investigation of problem areas.

22.p.1-20 Editorial change noted.

23.p.1-21 The uncontaminated areas of Sections 26 and 35 were classified as such based upon a thorough search of historical documents to include aerial photographs, written records and reports as well as personnel interviews. The number of borings located in these areas was based upon a decision by the Army to do some additional work to verify these areas as uncontaminated and our best technical judgement as to the adequately cover these large areas.

24.p.1-21 During the literature evaluation and research, no information was discovered concerning accidental spills in Sections 26 and 35.

25.p.3-1 Editorial change noted.

26.p.3-1 This report is titled "Selection of a Contamination Control Strategy for RMA" Volume II, USATHAMA, 1983. Your department already has a copy.

27.p.3-1 Based on the current limited use of Sections 35 and 26, it is felt that a wooden 4 x 4 will be sufficiently permanent for the purpose of the Phase I and Phase II investigations.

28.p.3-4 No fluids from the Basins will be sampled under this task, however, they may be under future task orders, under Task 4, or under Phase II of this program.

29.p.3-7 The approach taken in the UNC areas was to establish a grid with enough samples to conduct an unbiased search for contaminated areas that might be present. It was felt that a sufficient number of borings was drilled

that any downwind spread of contamination would be found and a more detailed Phase I investigation recommended.

30.p.3-7 The boring spacing in the uncontaminated areas is based on one boring per 562,500 $ft^2$. Assuming the bottom of the drainage ditches are approximately 20 ft in width, borings placed at 2,000 ft will yield one boring per 40,000 $ft^2$. Density of borings per unit area in the ditches is significantly greater than the density of borings in the uncontaminated areas. In addition, contaminant deposition in a drainage ditch is likely much more homogeneous, increasing the probability of detection with fewer bores.

31.p.3-7 In areas designated as uncontaminated the most likely contamination would be wind blown or from deposition at the surface to a few feet. The Army felt that there exists a sufficient volume of records that demonstrate these areas are uncontaminated. However, in order to be conservative a sampling program was devised in these areas to place borings and take soils samples to screen the areas to verify absence of contamination. This sampling was designed to produce the maximum data for a reasonable cost. A technical judgment among a group of scientists led to the decision of compositing. As far as dilution, if two one-foot samples are taken and the assumption was made that all the contamination was in one sample, the dilution would be 50 percent. Our technical judgment was that if high concentrations were present at any small interval, the concentrations found, even though slightly diluted, would trigger further investigation under a Phase II program.

32.p.3-7 See Question 31 for part of the response to this question. As far as the grid approach, the idea was to blanket each area whether suspected or known to be contaminated, or uncontaminated, with a number of samples to ensure all portions of RMA were included in the remedial investigation. No other program was ever implemented in these areas to analyze for the number of target compounds in this investigation. Historical data were used to help define the boundaries but no bias was introduced because of the few data points from past studies. Our approach was felt to be technically defendable and provide the most unbiased investigation possible that was geared to gathering the facts regarding contamination.

33.p.3-8 For source areas where liquids or waste waters have been present or sources where historical information suggests the presence of volatile

organics, soils from all boreholes will be quantitatively analyzed for purgeable organics. For sources where liquids, wastewaters, or volatile organics were not suspected from historical information only 10 percent of the soils will be analyzed for volatiles.

The indicator parameter TOC is not considered a method for identifying or quantifying concentrations of contaminants especially in near surface soils where the high background concentrations of natural organic matter in soil would mask any response of TOC values to the presence of organic contaminants.

The use of TOX as an indicator compound for identifying the presence of contaminants will not provide either identification of specific contaminants or quantifications of the concentration of that contaminant. TOX and TOC analyses will be discussed in more detail in the upcoming response to Task 14 comments.

34.p.3-9 Editorial change noted.

35.p.3-11 Editorial change noted.

36.p.3-11 The sewer lines were removed from these areas by a separate contractor. Samples from these areas were taken as soon as possible from the soils removed from the bottom of the trenches. A total of 24 samples were taken from the lines excavated in this area. An attempt was made to sample the lines felt to be most contaminated from the historical record review. Approximately 23 lines were located in this source as well as settling sumps and other process areas. Strong consideration for follow-up work is being considered not only based on the analytical results of the samples taken but also on the review of the facility's use.

37.p.3-11 Because of the large number of possible degredation products possible from the chemicals placed in Basin F, the GC/MS will be carefully reviewed to determine what non-target species are present in the volatile and non-volatile fractions of the samples. Also any immiscible phases or out-of-the-ordinary soil samples will be collected and analyzed at the direction of the field geologist. Soils with liquids are analyzed "as is".

38.p.3-14 Any sample from the source areas or UNC areas found to contain levels of chemicals in the Phase I investigation will trigger a more detailed Phase II study which would require additional drilling.

39.p.3-14 Editorial change noted.

40.p.3-15 The lists presented in the text are not all inclusive and only represent the type of chemicals that might be found. Both sources will be analyzed for the same list of chemicals and therefore treated the same.

41.p.3-22 A total of five boring locations have been established along the eastern boundary of Basin F in the vicinity where the extensive breaks in the asphalt lining were noted.

42.p.3-24 Editorial change noted.

43.p.3-31 The estimated quantity of uncontaminated area in Section 26 reflects the area of Section 26 not occupied by identified sources.

44.p.3-32 As explained in Comment 30, the density of borings in the Sand Creek lateral is actually more dense than the borings located in the uncontaminated areas of Section 26. It is our opinion that there are a sufficient number of borings located in the topographic lows and drainages of Section 26.

45.p.3-36 Editorial change noted.

46.p.3-42 There is a total of seven borings proposed along December 7th Avenue in Section 35. As the purpose of this study is to determine soil contamination within Section 35, it is our opinion that this is a sufficient number of borings.

47.p.3-43 The field geologist examines each core as it is obtained. As he inspects the core he may identify areas that appear to be damp or wet, possibly indicating chemical contamination, areas of discoloration and/or areas that show readings significantly above background on the air monitoring instruments. In any of these cases, he will select a sample interval in the area of apparent contamination and send it to the laboratory for chemical analyses regardless of whether this is an area previously planned for sampling.

48.p.3-43 An experiment was conducted on a sample of the polybutyrate liner to determine what interference might be present. A six inch sample was placed in a jar and covered with organic free water eliminating any head space. The jars were sealed and allowed to stand for five days. Several separate analyses were conducted on the water samples. Basically

relatively low concentrations of organic acids and plasticizers were found. This situation represented a worst case scenario. Because samples are much drier, this extreme would not be observed in the field. However, as a further precaution the samples taken for analysis are taken through the center of the core, well away from the soil/polybutyrate interface. We feel that this technique is technically sound.

49.p.3-45 The definition of the water table that will be used in the field is as follows:

1. The soil cores will be observed as they are removed from the hole. If, in the opinion of the field geologist, a saturated zone of soil exists, this will be considered the water table.
2. If visible signs of water are detected on the drilling equipment, i.e., the core barrel or drilling rod or standing water is observed in the borehole, these all will be considered the water table.

There exists the possibility that during periods of high precipitation the depth to water could change over time. However, in our opinion this change will not substantially effect the depths of the Phase I borings.

50.p.3-47 A procedure for hand sampling 1 foot deep borings is detailed on Page 3-48 of the Technical Plan.

51.p.3-47 Auger cuttings obtained from boreholes in identified contaminant sources will be removed as the borehole is advanced and placed in 55 gallon drums. The drums will be identified by borehole number and date. The disposition of the material contained within the drums will be determined upon review of the Phase I analytical results. In the interim, drums are being stored in Buildings 731 and 732, under functional RCRA guidelines as described by the EPA in the letter dated ______.

52.p.3-48 We agree that the procedure outlined for Shell split samples will not produce representative split sample analytical results. However, at the time Shell requested split samples. This procedure was the best available based on time and logistical constraints.

53.p.7-4 See comment Number 18.

54.p.8-1 All sampling points within the study area will be used to develop the Phase II Drilling/Sampling Program. The conditions A or B are categories that will use interpolation or extrapolation to determine where samples are positioned to best describe the area and depth affected by all or any of the target or possibly non-target analytes.

55.p.8-1 The contamination assessment involves more than just the data generated in this study. The information developed in this investigation will describe the chemicals present in the soil and whether they appear localized, fixed or mobile. Other parts of the assessment will require input from historical record review, development of guidelines for acceptable contaminant concentrations in soil and review of geologic conditions to assess the potential for migration. Review of the Phase I results, Phase II approaches, recently delivered to CDH, will provide more insight to the use of these results for defining Phase II.

56.p.1-3 Initially the sites were prioritized because of the pending litigation. The so called "Army Only" sites were postponed to Task 14, which has begun. All sources and uncontaminated areas are being investigated and will be integrated to achieve all requirements consistent with the NCP.

57.p.3-7-p.3-31 Windblown contamination from these basin areas in Section 26 would be scattered in a relatively uniform manner over a large area. We have attempted to position borings for the uncontaminated areas between and around the basins as well as on a grid pattern throughout the rest of the section. We have looked very hard at the spacing for these borings and felt that 750 ft centers would give us adequate coverage. Decreasing this spacing would increase the number of borings but in our opinion would not provide a substantial increase in our technical knowledge.

58.p.3-11 The purpose of the sampling to be conducted beneath the contaminated sewers located in the vicinity of the deep well is to provide soils contamination data from immediately beneath the removed sewers. If contamination is determined from the Phase I analytical results, a detailed Phase II investigation will be designed to determine the lateral and vertical extent of contamination.

59.p.4-3 The parameters listed in this question are pertinent to the analysis of water samples but have little or no bearing on the soil contamination at RMA especially during the screening phase of this Remedial Investigation. A more thorough discussion for our position on the TOC and TOX use for soil sampling is being prepared and will be furnished to you in the future. Most of the remaining inorganic parameters would be found in substantial concentrations naturally and in our opinion it would not be technically sound to develop a costly screening program. We feel that the money that would be spent on these analyses would be best used to

ensure completeness of the proposed Phase II investigation particularly at sources found to contain environmentally hazardous materials.

Shell Oil Company

One Shell Plaza
P.O. Box 4320
Houston, Texas 77210

October 24, 1985

Commander
USATHAMA
Bldg E4435, 2nd Floor
AMXTH-AS-O/Mr. Don Campbell
Aberdeen Proving Ground, Maryland 21010-5401

Dear Mr. Campbell:

The following responds to your memoranda, one undated and one dated October 4, 1985, requesting Shell's comments on, respectively, Tasks 4 and 6, and 7 and 12.

Shell's ability to provide comment on the Army's remedial investigation programs for the RMA sections covered by these tasks is constrained because the Army has quite clearly distorted severely the scopes of these tasks, apparently for litigation reasons. The result is that the work proposed is gravely deficient from the required perspective of remedial investigation undertaken pursuant to CERCLA and the National Contingency Plan.

The scopes of these tasks (and Tasks 1 and 2 as well) are incomplete in two important aspects. First, while emphasizing identification of Shell compounds throughout, the tasks do not address Army compounds which logically could be expected to be present in the environment. In its letter to you dated July 29, 1985, Shell identified a list of Army compounds which Shell believes should be considered for inclusion in RMA remedial investigation programs. None of these compounds is included in these four new tasks. Second, coupled with the above, contamination sources associated with Army activities are excluded from the task scopes. For example, of the nineteen (19) Contaminant Sources listed in Table 1.1-1 only ten (10) are treated in proposed remedial investigation programs in the Task 6 plan and of these only six (6) will be done in Task 6. Five of the sites have been designated as uncontaminated without providing the methodology or results. Such arbitrary classification of contaminant sources into different tasks to be done at different times impedes constructive comment because it conceals from reviewers integral portions of the remedial investigation. We do not

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believe either that such an approach fosters competent remedial investigation, and it appears certain to frustrate a coherent and integrated product.

In the spirit of cooperation and in view of the impediments described, Shell is providing in attached tables technical comment on these tasks.

Sincerely yours,

R D Lundahl

for C. K. Hahn
Manager
Denver Site Project

RDL:ajg

Attachment

cc: (w/attachment)
Mr. Thomas P. Looby
Office of Health Protection
Colorado Department of Health
4210 East 11th Avenue
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Mr. Robert L. Duprey
U.S. Environmental Protection Agency
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Mr. Thomas Bick
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Major Robert T. Boonstoppel
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Washington, DC 20044

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SHELL CHEMICAL COMPANY

COMMENTS ON DRAFT FINAL TECHNICAL PLAN, SEPTEMBER 1985
TASK NUMBER 6, SECTIONS 26 AND 35 CONTAMINATION SURVEY

Section 3.3.1.1, Boring Program, page 3-11.
Borings at pipe joints should be specified rather than to depend on reduced boring spacing to by chance provide some pipe joint samples.

Section 3.3.3.8, Uncontaminated Areas, page 3-31.
The historical record would indicate sources 26-2 and 26-10 and areas north and northeast of Basin F have been potentially exposed to contamination from drift of droplets from spray raft operations. Therefore, this area should be designated as a Contaminant Source.

Section 3.3.1.9, Contaminants, page 3-33.
The chemical sewer also transported waste streams from Army's activities in the South Plants area.

Section 3.3.1, Source Conditions and Boring Program, page 3-8.
The statement is made that there was no evidence during this review that surety material would be present in either Section 26 or 35. Surety degradation products and manufacturing intermediates and by-products are more likely to be present. Have any analyses been done in Sections 26 and 35 on these compounds? A reasonable basis exists to suspect that these contaminants could be present. For example, the last paragraph on page 3-10 states that contaminants in sewers in Sections 26 and 35 would in general include any of the wastes from the manufacturing facilities located on RMA. Also, on page 3-12 it is stated that Basins B and C and associated ditches received overflow from Basin A and that aerial photographs indicate the presence of standing liquid in Basin C as early as 1948. Basin A received industrial wastes and waste waters from 1941 until 1956, according to Task 1 plan at page 1-3.

Section 3.3.1, Figures 3.3-3, 3.3-4, 3.3-5, 3.3-6.
All boring samples for the basins are located within basin boundaries. It would be advisable to take some borings immediately outside of the basins because lateral migration might have occurred due to lateral dispersion and/or lateral spills.

Mr. Campbell/tmm/3261
Retyped: 4 Dec 85

DPM

December 9, 1985

Office of the Program Manager

Mr. Chris Hahn
Shell Oil Company
1 Shell Plaza
900 Louisiana Street
Room 1316
Houston, Texas 77002

Dear Mr. Hahn:

This letter is in response to your letter dated October 24, 1985 in which you commented on the Army's Remedial Investigation (RI) Tasks 4, 5, 7, and 12.

It is extremely disappointing that after numerous informal face to face discussions and frequent meetings between Shell and the Army technical representatives over the last year, Shell feels compelled to ignore information provided to it orally and express its concern over the Army's RI program within paragraph 2 in such a critical manner.

The Army remains confident that the RI program being carried out at Rocky Mountain Arsenal is fully consistent with and fully satisfies the Comprehensive Environmental Response Compensation and Liability Act and the National Contingency Plan. Our RI program has been developed after considerable consultation with independent experts and the U.S. Environmental Protection Agency. Except for the timing of the individual tasks (discussed below), the RI program being conducted at the Arsenal has been structured to be independent of the ongoing litigation between Shell, the State of Colorado, and the U.S. Government.

Both fundamental issues raised in paragraph 3 of your letter have been addressed in the past, most recently during the Memorandum of Agreement meeting on September 4, 1985, in the meetings with Shell at Aberdeen Proving Ground on September 9, 1985, and during the On-Post Task Group Memorandum of Agreement meeting on September 17, 1985. An enclosure to the minutes of this last meeting contained schedules for all field programs. To ensure that the record is complete on these issues, the following response is provided:

a. Selection of Analytical Compounds - The Army's approach to identify and quantify key analytical compounds in the environment, out of the vast array of compounds previously used at Rocky Mountain Arsenal (over 500 inorganic and organic constituents), is the much discussed Phase I (identification)/Phase II (quantification) sampling and chemical analysis program. As described to you before, Phase I studies of the entire Arsenal utilize both gas chromatography/mass spectrometry (GC/MS) methods capable of screening for thousands of organic compounds and use of the

Inductivity Coupled Argon Plasma (ICAP) method which screens for metals. Those Phase I studies, which are ongoing, have targeted approximately 60 compounds for semi-quantitative determination to aid in early delineation of source strengths/boundaries. It may be true that Shell's compounds make up a substantial portion of this early 60 compound "hit list." However, this came about not because of any arbitrary pre-meditation to single out Shell, but because Shell compounds are widely dispersed throughout the installation and possess important toxicity and persistency characteristics. The Phase I hit list includes a number of compounds indicative of specific waste streams. For example, potential chemical agent mustard contamination is assessed by analyzing not only for mustard itself, but also dithiane and oxathiane, two principal decomposition products. Phase II of the RI studies are presently being formulated based on both Phase I results (semi-quantitative data on the hit list compounds and screening data on the entire host of compounds suspected of being present) and knowledge of individual site history. Each Phase II investigation analytic list will thus be customized to the contamination site. Specific gas chromotograph (GC) and atomic absorbtion (AA) methods are being designed for Phase II to quantitatively analyze for compounds of concern. Based upon early valid concerns raised by Shell, the Phase II compound list will include several constituents not amenable to Phase I screening techniques such as thiodigycol, total organic arsenic compounds (e.g., lewiste oxide), total organic mercury compounds (e.g., methylmercury) isopropylmethyl phosphonic acid and trimethyl phosphide.

b. Selection of Contamination Sources - In the above referenced meetings with Shell, we have repeatedly discussed our philosophy of RI studies pertaining to soils and buildings at Rocky Mountain Arsenal. Because of both the vast number of contamination sites (over 150 individual locations) and Government contracting procedures, we must approach the RI studies in a staged, progressive manner. Priority has been given to the most contaminated sources first. Because of ongoing litigation, those sites potentially containing a mixture of Army and Shell contaminants have been given timely attention for input to upcoming trial milestones. Army sites, not part of the Shell lawsuit, have been prioritized last and thus are not included in the current Phase I plans forwarded to your company. By the end of June 1986, all contamination sites will have been investigated in Phase I irregardless of former site usage. The Phase I methodology involving the number of borings and analytic parameters/field procedures being utilized has been standardized thereby previewing to the reviewers all portions of our initial RI program. In addition, at the latest On-Post Memorandum of Agreement Task Group meeting, a package containing color-coded maps, schedules, and tentative milestones was distributed to all attendees.

I hope that the above discussion clarifies and resolves perceived impediments documented by Shell. If there are any further questions, please call me at (301) 671-3261.

Sincerely,

/S/ DLC

Donald L. Campbell
Special Litigation Team Member

Copies Furnished:

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Mr. Edward McGrath, Holme Roberts and Owen, 1700 Broadway, Denver, Colorado 80290
Ms. Catherine McCabe, Environmental Enforcement Center, Land and Natural Resources Division, U.S. Department of Justice, Washington, DC 20530
Mr. Tom Bick, Environmental Enforcement Section, Land and Natural Resources Division, U.S. Department of Justice, P.O. Box 7415, Benjamin Franklin Station, Washington, DC 20044-7415
Mr. David Strang, Office of the Program Manager for Rocky Mountain Arsenal Contamination Cleanup, Attention: AMXRM-PM-R, Commerce City, Colorado 80022-2180
Mr. Robert Duprey, U.S. Environmental Protection Agency, Region VIII, 1860 Lincoln Street, Denver, Colorado 80295
Mr. Tom Looby, Colorado Department of Health, 4210 East 11th Avenue, Denver, Colorado 80220

**RESPONSES TO**
**SHELL CHEMICAL COMPANY**
**SPECIFIC COMMENTS ON THE**
**TASK 6 DRAFT FINAL TECHNICAL PLAN**

Section 3.3.1.1 Boring Program, Page 3-11

The trace of the chemical sewer line (Site 35-2/26-9) will be investigated during Task 14. This line was removed in 1982. Soil borings will be located and sampling depths determined using the Facility Engineering "as built" drawings. Pipe joint locations cannot be determined from these documents; therefore, boreholes will be located near former manholes where leaks were most likely to have occurred.

The sampling program at the sewer lines servicing the Deep Injection Well Facility (26-1) and Basin F (26-6) will be scheduled to coincide with the excavation and removal program. The sampling teams will attempt to sample the soil underneath the lines immediately after removal. Samples will be collected beneath pipe joints or locations where the soil has been discolored by leaking fluids.

Section 3.3.8.8 Uncontaminated Areas, Page 3-31

The possibility that airborne contaminants from Basin F have affected the uncontaminated areas of Section 26 will be addressed during the Phase II program. Surficial (0-1 ft) soil samples will be collected at 25 locations outside the basin along the vectors corresponding to high frequency wind directions.

Section 3.3.1.9, Contaminants, Page 3-33

Editorial change noted.

Section 3.3.1 Source Conditions and Boring Program, Page 3-8

A comprehensive review of RMA documents and field reconnaisance did not reveal any indication that Army agents or agent containers,

empty or full, were disposed anywhere in Sections 26 or 35. It is thought that any agent compounds ultimately discharged into these sections were part of aqueous waste stream in the Basin A-B-C ditches, the chemical sewer, or the Sand Creek Lateral. Agent compounds or byproducts in these waste streams are expected to have been oxidized or otherwise degraded. The Phase II program will include specific analyses for agent degradation products.

Section 3.3.1 Figures 3.3-3, 3.3-4, 3.3-5, 3.3-6

The Phase I program is intended to quantify the volume of contaminated soil within each basin and investigate the validity of the basin boundaries as currently designated. Based on the Phase I results, the Phase II borings will be located to further establish the areal and vertical extent of contamination within and outside each basin.